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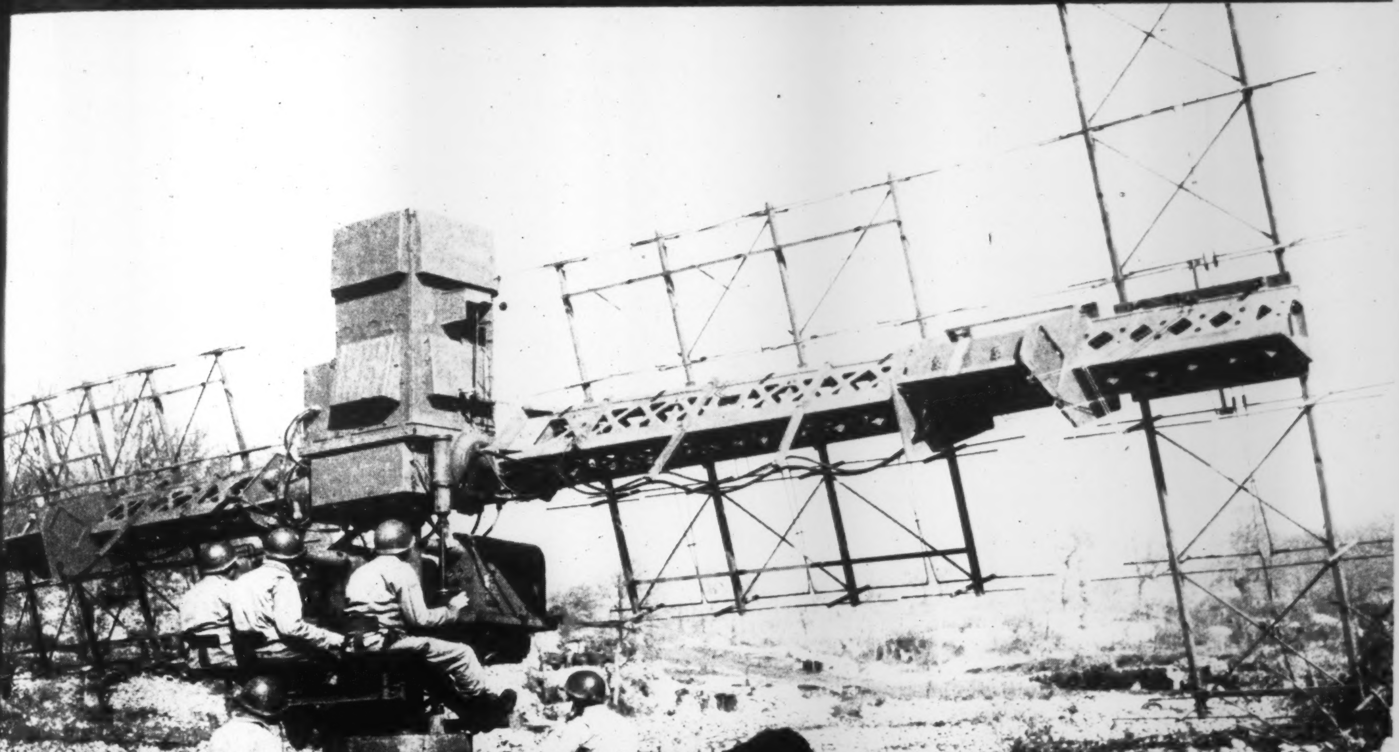

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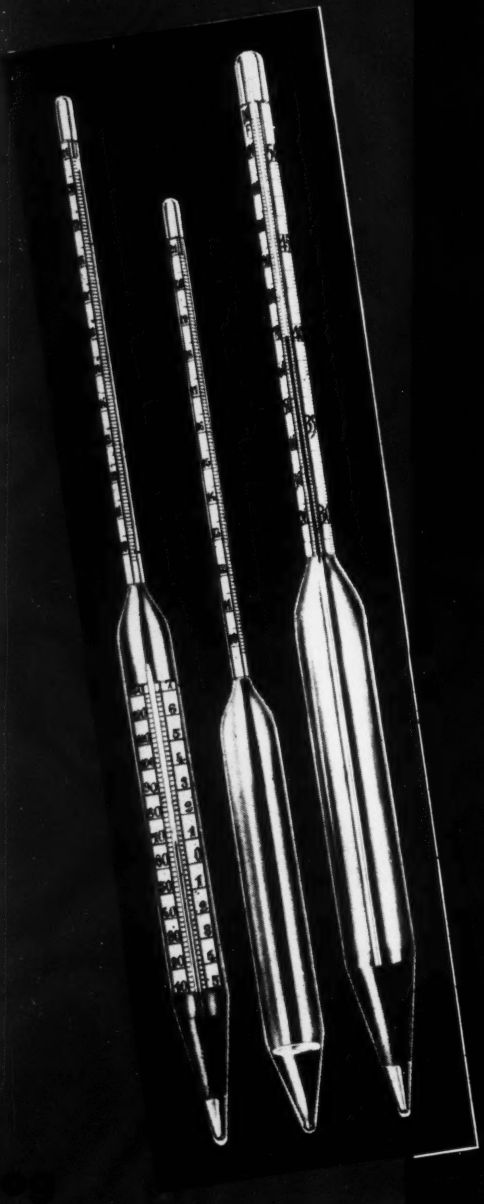

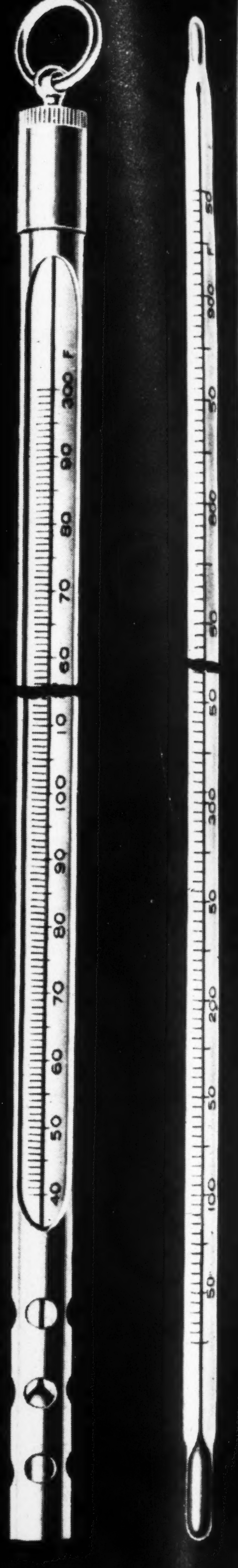

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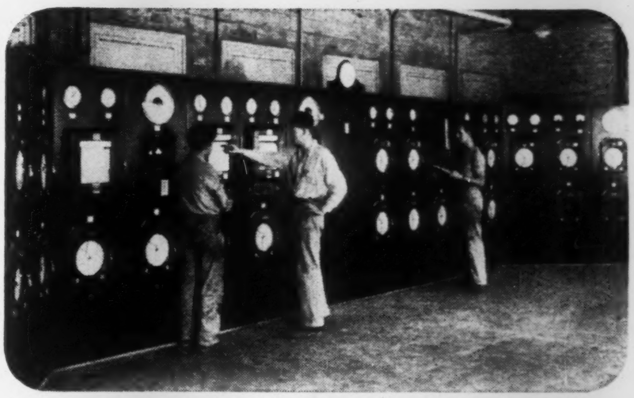

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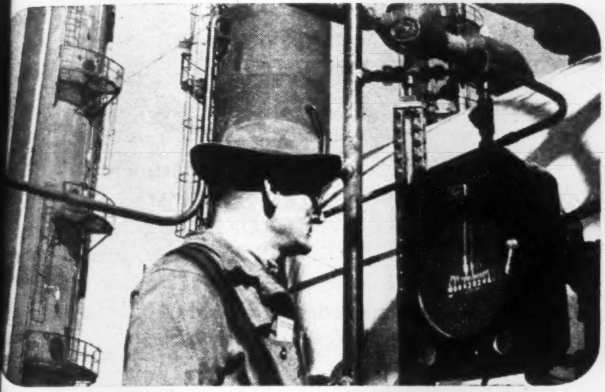
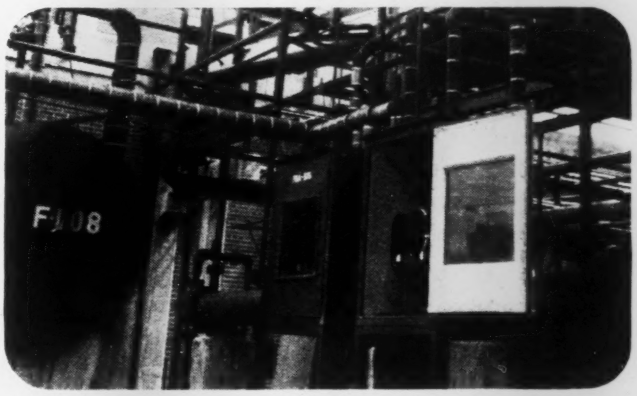


2. Want accurate control of liquid level? For the huge Port Neches synthetic rubber project we sup-lied both buoyancy and ball float type Taylor Level ontrollers (above) as well as hundreds of other Taylor nstruments. Taylor controls were standard equipment n the vital polymerization process in all plants.



3. These flow transmitters are part of the Taylor instrumentation for Utah Oil Refining Company in the Salt Lake City plant built as an ace-in-the-hole against the chance of Jap bombing of Coast refineries. At left, extraneous butanes feed flow transmitter. Right, depropanizer bottoms flow transmitter.

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Instruments

Vol. 18 **September 1945** No.

COVER: Radar set SRC-288 with five-man crew in operation o an Italian hillside. The three operators seated on the mou see indications of the airplane echo on cathode ray oscill scopes. One operator tracks the aircraft in azimuth; anoth operator tracks in elevation; the third measures the rang *(U. S. Army Photograph)*

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

At Last the Term "Magic Eye" is Fully Justified

IN 1935 there was developed a new type of voltmeter operating on the cathode-ray-deflection principle and indicating the approximate value of the impressed potential by the angle of a fluorescent sector on a circular target.* Manufactured in the shape and size of a radio tube, it soon began to be incorporated in home radios as a tuning indicator. Its official designation was "6E5" . . . BUT:

Seen through the rounded end of its glass tube, the target structure of the 6E5 resembled the iris and pupil of the human eye. Any three-year-old child could see this resemblance at a glance; it took only a few months for the home radio industry's advertising men to see it. Result: the term "magic eye" was shouted in print and on the air so loudly and persistently that even serious engineers found themselves using it—in spite of the fact that this term, when applied to the 6E5, is uninspired, unimaginative and as untruthful as if it were applied to a door-knob.

Perhaps we're too hard on the home radio industry's admen: for the general public they had to use a better name than "6E5" or "tuning-indicator." They couldn't think up anything new (and in million-dollar national advertising campaigns it's risky to be original, profitable to be imitative) so they borrowed or appropriated the term "magic eye" from the writers who had used it during the preceding hundred years to describe great telescopes, improved microscopes and other *optical* instruments.

THAT was a legitimate use, because optical instruments ARE extensions of our sense of vision and each invention in the field of optics deserves (before the wonder wears off) such adjectives as "amazing" or "magic."

The true "magic eyes," of course, are those instruments which extend our vision not so much by magnifying visible images but by transmitting images (television) or by making visible that which is invisible to the combination of a human eye and telescopic or microscopic lens systems. That is to say, those instruments which utilize other radiations than the visible spectrum and which convert the resulting images into visible images.

There had been a glorious procession of such instruments before the war: the x-ray fluoroscope, the ultraviolet microscope, the electron microscope, the infrared iceberg-alarm, the sonic iceberg-alarm, the fathometer and various other sonic navigation instruments for ships, the absolute altimeter for aircraft, etc., etc. . . . AND the various pre-Pearl Harbor radar instruments being experimented with by many companies as well as by the Armed Forces and the OSRD's Radiation Laboratories at MIT.

Yes, many radars were made before Pearl Harbor. Why didn't we print any articles on radars at that time? For three reasons: (1) The term "radar"—contraction of Radio Detection and Ranging—was censored from the moment it was coined; (2) the few disclosures by pioneer research workers were too theoretical and fragmentary to be of interest to *Instruments* subscribers; (3) no disclosures at all were made of the pre-Pearl Harbor radars manufactured for our Armed Forces, such as the Westinghouse-made instruments by means of which Private Lockard detected the sneak-attack Jap planes at a distance of a hundred miles from Pearl Harbor.

In mid-August 1945 censorship was lifted partly—just enough for fascinating portions of the story of American war-time radar developments to be told. Now—in late August—many enterprising companies that were members of the glorious team are beginning to make known their achievements no longer subject to censorship. Most of the participating companies are preoccupied with reconversion and have not yet assigned engineers to write special articles for selected magazines such as *Instruments*. The unfolding of technical instrument details will necessarily take many months: it may not even *begin* until our December issue.

Meanwhile, in accordance with our long-cherished intention to print an article giving a general or semi-technical picture of radar instrumentation in the very first issue after the first partial lifting of censorship, we have accepted one which meets almost all of our ideal specifications. It appears on pages 604-610.

At the beginning of his article Mr. Reynolds divides all radars into the "search" type and the "fire control" type. This might be a military basic classification* but from the viewpoint of the instrument man (and of methodology) it seems to us that the two basic categories are:

1. Instruments providing MEASUREMENTS of the distances and directions of objects invisible to the human eye by reason of fog, clouds, darkness, earth curvature, etc. This type has been improved until distances are measured to ±0.5% and bearings to less than a minute of arc, so that the prime essential of defense against future ocean-crossing mile-a-second A-bomb rockets is already a fact.**

2. Instruments providing IMAGES of their fields of "view" in darkness or through clouds (see picture on page 608). This is the type which made possible what the censors allowed newsmen to call "instrument bombing." This is the type affectionately called "Mickey" by the AAF and "Stinky" by the RAF. *This is the Magic Eye!*

The number of peace-time uses of each of these two categories stumps the imagination. It is safe to predict that airport and aircraft applications of the magic-eye or viewing-screen type will probably be made before the end of this year: this probability is known to every reader who remembers the article by Glen Gilbert of the CAA in our April 1945 issue, illustrated with pictures of the screens of two types of aircraft magic eyes: one a collision-warning instrument, the other a traffic-control instrument. The exact-measurement type also will soon be installed at airports and at Weather Bureau stations: among other things it can do immediately is to track meteorological balloons in spite of clouds or ultra-theodolite distances. —MFB

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*Dayton Ulrey: "New Electronic Tubes and New Uses." *Physics*, Vol. 7, 1936, pages 97-105. Also, for brief illustrated description, *Instruments*, Vol. 9, 1936, page 231.

*Even as a military classification scheme it appears to be defective because there are other military types such as "warning radar," "microwave early-warning radar," "ground-controlled-approach radar," etc. (These are only some of the Army types: the Navy censors have hardly begun to lift the veil and it may be years before they release technical details of the many types of radars used on ships, on aircraft, in projectiles, etc.)

**Lest we be misquoted, we wish to emphasize that this is *only the prime essential* of such defense, for we know full well that although radar made possible the interception of the relatively slow V-1 robombs (95% effective at the end) it had not yet been perfected sufficiently to cope adequately with the much-faster V-2.

The Solution of Instrumentation Problems by the Pneumatic Null Balance Method*

By C. B. MOORE, Moore Products Co., Philadelphia, Pa.

IT is well known that null balance methods are extremely accurate methods of measurement. The pneumatic null balance system is simply another form of the same null principle. The word "null" is generally thought of in terms of electric circuits—particularly bridge and potentiometer circuits in which the amount of unbalance is indicated by the deflection of a galvanometer. The early pneumatic transmission systems† were of the displacement type in which the bellows element took a new position for each new value of the measured variable.

It is the purpose of this article to explain the pneumatic null balance system, divorcing it completely from electric circuits, and so presenting it as to show the various ways in which it can be applied to solve instrumentation problems.

This pneumatic null balance principle has played an important part in the solution of instrument problems in connection with the production of the atomic bomb. Special modifications in design and construction, including protective features, were necessary to suit the specific requirements of the project. This work was carried on in coöperation with the War Research Department of Columbia University and with The Kellex Corporation. National security prevents the disclosure of details incorporated in these special instruments.

PRINCIPAL CHARACTERISTICS OF THE PNEUMATIC NULL BALANCE METHOD

Comparing this method with the displacement method, certain characteristics may be pointed out. (It is assumed in all cases that a flexible member, such as a diaphragm or metallic bellows, is required to detect changes in the measured variable.)

1. Elimination of non-linear characteristics of the flexible member.
2. A material increase in the life expectancy of the flexible member.
3. Increased ability to respond to small changes, without impairing the design by using a long travel of the measuring element.
4. Elimination of all sources of frictional error which would be introduced by the use of pivots, bearings, and sliding members.
5. Elimination of levers, cams, or other motion-transmitting members which are required in a design using the displacement principle.
6. No possibility of wear in any of the components, because of the elimination of mechanical contact in a pneumatic null balance system.
7. Calibration not affected by variation in spring rate of the flexible member; effect on the zero position correspondingly neglible. (The absence of an appreciable change in zero position is predicated on the use of flexible members with a low spring rate, and on operation in the neutral or free position, when in balance.)

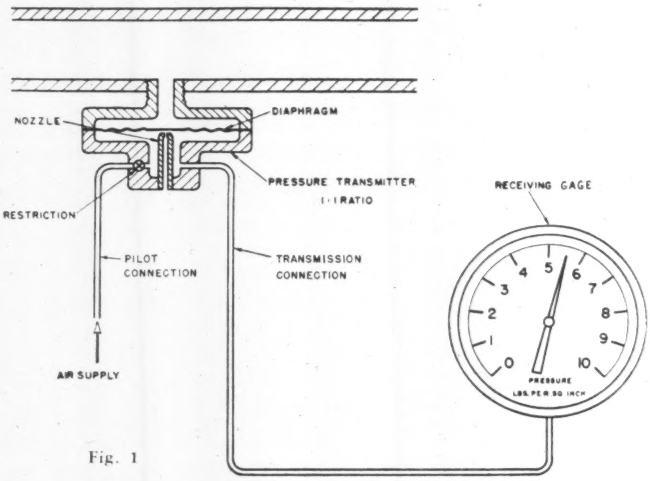


Fig. 1

DESCRIPTION AND SUMMARY OF DESIGN FACTORS

Fig. 1 illustrates the simplest form of the pneumatic null balance circuit for reproducing pressures in a one-to-one ratio. The measured pressure in the pipe or vessel is balanced by air pressure on the diaphragm in a 1:1 ratio, since the effective area is the same on both sides. Any change in the measured pressure tends to deflect the diaphragm, which partly opens or closes the port in the exhaust nozzle, allowing the balance pressure to change to essentially the same extent. The source of power is obtained from the air supply, which enters through a fixed restriction to the balance chamber, connected directly to the calibrated receiving instrument. The detecting nozzle exhausts directly to the atmosphere and is responsive to the slightest change in measured pressure. (This circuit may be designated as a "direct nozzle" system.)

There are a number of factors which influence the design of a unit as simple as that of the pneumatic null balance system. These factors may be summarized as follows:

(1) *Nozzle Characteristics.*—In order to reproduce the pressure resulting from the measured variable, the flexible member must take a position of equilibrium with respect to the exhaust nozzle. As this measured value increases, the flexible member, or diaphragm, must take a position slightly closer to the exhaust nozzle, in order to maintain the higher transmitted pressure in a state of equilibrium. This means that the nozzle clearance will vary slightly for each change in value of the transmitted pressure. As shown on Curve "A" of Fig. 2, this is definitely nonlinear in its characteristics.

The change in position, with respect to the nozzle, can be reduced by (a) decreasing the size of the restriction, or (b) increasing the size of the nozzle. Both these modifications would result in a closer clearance between the flexible member and the nozzle, when the transmitted pressure is at full-scale value. This would require more accurate manufacture and alignment of the components, to prevent the flexible members from touching the nozzle. There is, therefore, a practical limit to the permissible clearance which can be used; thus, it follows that the nonlinearity cannot be completely eliminated with use of the "direct nozzle" system.

Curve "B," Fig. 2, shows the resulting nozzle characteristics when the pressure drop across the nozzle is maintained constant for all values of transmitted pressure. (The booster pilot valve, used to obtain the constant differential, will be explained in this article.)

In order to reduce the non-linearity of the transmitted pressure, the circuit using the direct nozzle system must necessarily transmit a "live" zero reading when the measured pressure is zero.

---

*Substance of a lecture presented before the New Jersey Society for Measurement and Control in October 1943; and before seven other instrument societies since then; also before seven large groups of instrument men and operators at the Oak Ridge plant of the atomic bomb project.

†See article on "Pneumatic Telemetering" in the September 1937 issue of *Instruments*, pages 242-243, 248.

It is general practice to make this a value of 2 or 3 lbs./in.^{2}. Curve "B" shows that the magnitude of this difference between measured and transmitted pressure may be reduced, if desired, without impairing the performance.

The "live" zero also serves a practical function in the event of failure of the air supply, by causing the receiving instrument to read below the zero value of the measured variable.

(2) *Spring Rate of the Flexible Member, Compared to Full Range of the Measured Variable.*—If the diaphragm is infinitely flexible, it will have a zero spring rate, and the nozzle characteristics will in no way affect accuracy in reproducing the measured pressure. In practice, the spring rate is always a finite value and, therefore, it becomes a factor in the accuracy of transmission. Let us assume that the diaphragm has a spring rate of 150 lbs./in. of travel, and that it has an effective area of 5 in.^{2}. If the full-scale range were from 3 to 18 lbs./in.^{2} the diaphragm would be capable of moving 0.005" for a 1% change in the measured variable. Curve "A" of Fig. 2 shows that when the transmitted pressure range is 3 to 18 lbs./in.^{2} the change in position with respect to the nozzle is 0.0024. Since this is 0.48% of the range of the measured pressure, it would mean that the range of the reproduced pressure would be 0.48% less. This can be corrected, of course, by calibrating the receiver to read in the units of the measured variable, except for the fact that the error introduced is non-linear. The straight line drawn between 3 and 18 lbs./in.^{2}, on Curve "A," shows that the maximum deviation from true linearity is a movement in the amount of 0.0008". This means that the deviation from true linear reproduction of the measured pressure will be in error by 0.16%. It can be seen from the foregoing data that the accuracy of reproducing the unknown pressure is a function both of (a) the spring rate of the flexible member and (b) the characteristics of the exhaust nozzle.

(3) *Effective Area of the Flexible Member.*—The full-scale spring rate of the system may be controlled by selection of the size and thickness of the diaphragm. It is necessary to provide sufficient over-range protection to avoid a permanent deformation when the air supply is off. The flexible member must also be protected when full air supply is directly on the diaphragm, with the measured pressure at zero. It is normal procedure to provide limit stops to prevent the flexible member from moving more than a predetermined amount. These stops can be located quite close to the normal position because of the extremely small motion necessary for full-scale measurement and transmission.

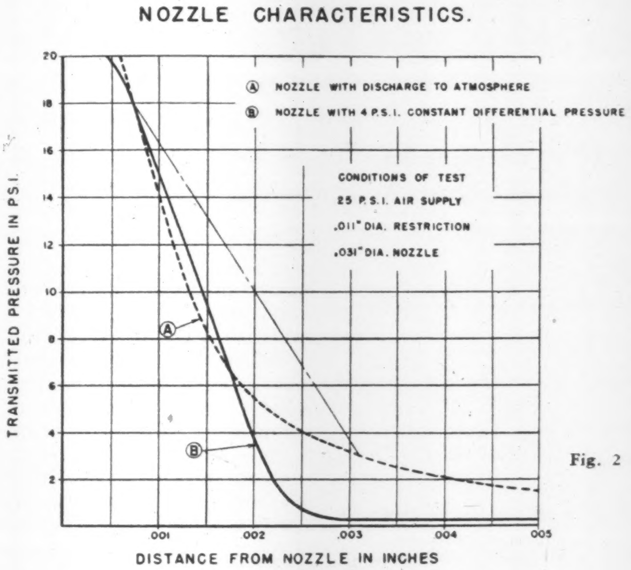


Fig. 2

(4) *Materials of Construction.* — In many applications, a diaphragm material must be used which will resist the corrosive action of the fluid measured. In certain applications, the metal most suitable will be completely lacking in elastic properties. In these cases, the diaphragm, or flexible member, can be made with the non-elastic material bonded to stainless steel, phosphor bronze, or some other suitable resilient metal. A fabric-inserted diaphragm of rubber, plastic, or other synthetic material can be used in a number of applications; but the diaphragm must necessarily be in its slack position, as, otherwise, over a period of time, the creep characteristics would cause a serious change in the zero position.

(5) *Range of Measured Variable.*—The use of the 1:1 transmitter has a practical limit in its application to various ranges of measured pressure. This practical upper limit is determined by the availability of a high-pressure air supply. A higher transmitted pressure will also involve a greater air consumption, which, in certain applications, may be the limiting factor, from the standpoint of economy. It should also be noted that a wider range of measured pressure will increase the non-linearity of the nozzle characteristics. If it is necessary to measure a small range of pressure at a higher value, it is a relatively simple matter to introduce a loading spring on the transmitted side. This will suppress the portion of the range for which readings are not necessary. Since the null balance system is used, this spring will always remain essentially in its initial position. The transmitting system will require a lower air supply and use less air. This will result in a greater percentage of accuracy in the transmitted values.

Extremely small ranges of pressure measurement will be limited by the ability to obtain a low enough over-all spring rate for the entire system. Practical considerations in the physical size of the flexible member are also a very definite limiting factor.

On sub-atmospheric measurements, the same circuit applies, requiring a continuously-operating vacuum connection to the exhaust nozzle. In the preceding applications, the discharge was to the atmosphere as a reference pressure. When a vacuum connection is used, the reference pressure becomes substantially zero absolute. This permits the use of atmospheric air as a source of supply and obviates the necessity of maintaining a regulated pressure. If the "live" zero transmission is not used and the measured pressure is the same as the transmitted pressure, there is a lower limit, below which it would be impractical to transmit. Because of the volumetric expansion of the gas, it becomes obvious that the design of the nozzle diameter would approach infinity, as the transmitted pressure approached absolute zero. With 1 or 2 lbs./in.^{2} difference between transmitted and measured pressure, a zero absolute value can readily be measured, without exceeding practical limits in the design of the exhaust nozzle or the capacity of the vacuum pump.

TRANSMITTER WITH CONSTANT DIFFERENTIAL ACROSS THE PILOT NOZZLE

In the null balance system described, increase in nozzle clearance with decrease in transmitted pressure results from (a) increase in air flow due to the increased differential across the supply restriction, (b) expansion of the air, and (c) decrease in the differential across the nozzle. These factors are more or less non-linear in their effect on the nozzle characteristics.

The last of these effects could be largely eliminated, if the differential across the nozzle were held constant; Curve "B," Fig. 2, shows the nozzle characteristics obtained when this is done. Within the operating range, this curve has considerably less deviation from linearity than the characteristic curve of the "direct nozzle" system.

Fig. 3 illustrates diagrammatically a means of maintaining the constant differential by introducing a booster pilot. This booster pilot also serves the additional function of providing a large flow capacity for long-distance transmission, and of reducing the error resulting from slight leaks in the lines.

When pneumatic circuits are analyzed, it usually is the practice to trace the sequence of operation step by step, following the direction of flow. This ordinarily results in some confusion, and does not leave a clear picture of the circuit. An alternate method of visualizing the functions as occurring simultaneously will create a far clearer picture of any type of pneumatic circuit. The null balance system lends itself particularly well to such an analysis. The forces in balance can be considered in their state of equilibrium, to clarify the entire operation of the circuit.

As shown in Fig. 3, equilibrium in the booster pilot is attained when the pressure above the diaphragm is greater than that below the diaphragm, by an amount which balances the force of the loading spring. The difference between these two pressures is substantially constant; it is this differential which is effective across the nozzle in the transmitting unit. Any departure from equilibrium will be corrected by appropriate action of the inlet or exhaust valves, operated by the diaphragm.

A second condition of equilibrium exists at the diaphragm of the measuring unit when the transmitted pressure equals the measured pressure. An unbalance in these pressures will change the nozzle opening and affect the pressure above the booster diaphragm. Equilibrium will again be restored, however, by action of the inlet or exhaust valves.

The air for operating this balance system flows from the supply line through the fixed restriction and pilot nozzle and eventually to the transmission line. With no leaks in this line, the air exhausts to the atmosphere through the automatic bleed port of the booster pilot. An increase in required transmission pressure temporarily closes this exhaust and opens the main port to raise the pressure the required amount. With a decrease in required pressure, the automatic bleed opens a greater amount, until equilibrium has again been reached.

TYPICAL EXAMPLES OF UTILIZATION OF THE PNEUMATIC NULL BALANCE PRINCIPLE IN SOLVING INSTRUMENTATION PROBLEMS

1. *Amplifying Pressure Transmitter*

In the event that the measured pressure range is too small to be suitable for application to a pressure-gage receiver in a 1:1 ratio, Fig. 4 illustrates a method of introducing an amplifying bellows to multiply the readings in a fixed ratio. This ratio of amplification will be the ratio between effective areas of the diaphragm and transmitting bellows. In practice, a combination of diaphragm and bellows, as illustrated, is rarely used, because the effective area of a diaphragm varies noticeably with pressure and position, so that the combination would not have a constant ratio of amplification. On the other hand, metallic bellows have a relatively constant effective area and, for this reason, would ordinarily be used in place of the diaphragm shown in this and the following schematic illustrations.

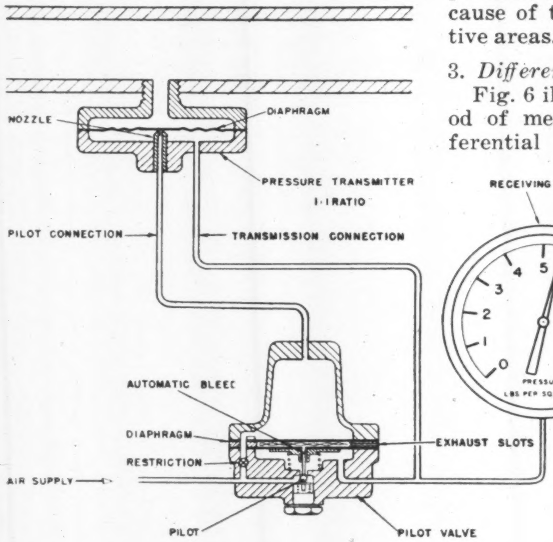

NOZZLE
DIAPHRAGM
PRESSURE TRANSMITTER
1:1 RATIO
PILOT CONNECTION
TRANSMISSION CONNECTION
AUTOMATIC BLEED
DIAPHRAGM
RESTRICTION
AIR SUPPLY
EXHAUST SLOTS
PILOT
PILOT VALVE
RECEIVING GAGE
0
1
2
3
4
5
6
7
8
9
10
PRESSURE
LBS PER SQ INCH

Fig. 3

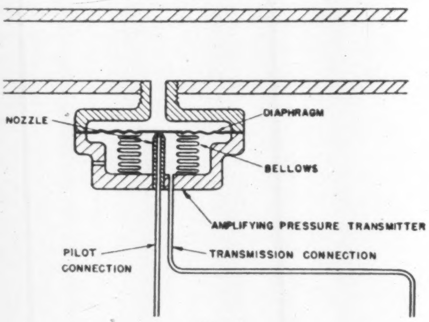

NOZZLE
DIAPHRAGM
BELLOWS
AMPLIFYING PRESSURE TRANSMITTER
PILOT CONNECTION
TRANSMISSION CONNECTION

Fig. 4

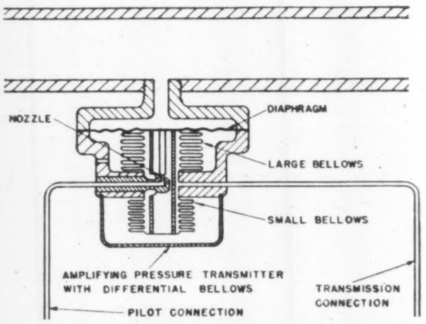

NOZZLE
DIAPHRAGM
LARGE BELLOWS
SMALL BELLOWS
AMPLIFYING PRESSURE TRANSMITTER WITH DIFFERENTIAL BELLOWS
TRANSMISSION CONNECTION
PILOT CONNECTION

Fig. 5

2. *High-range Amplifying Pressure Transmitter*

The preceding illustration is limited in its amplifying factor by physical size and by the spring rate of the small transmitting bellows, to a ratio of approximately 25 to 1. Fig. 5 illustrates a method of maintaining the same size of measuring element and using the transmitting bellows differentially. By this method, the transmitting-bellows differential-effective-area can be made relatively small, without increasing the over-all spring rate to an impractical figure. There are, however, many practical limitations to this method—such as the effect of ambient temperature changes on the zero position; these changes place a practical limit of approximately 100 to 1 on such a design. Ratios can be selected as high as several hundred to one, but this would present manufacturing difficulties because of the variation in bellows effective areas.

3. *Differential Pressure Transmitter*

Fig. 6 illustrates a null balance method of measuring and amplifying differential pressures for transmitting values of flow, liquid level, interface level, and specific gravity. It is identical with Fig. 4, except that an additional bellows has been added above the measuring bellows. This must have the same effective area as the transmitting bellows, in order to compensate for variations in static pressures. In the case of the single-pressure transmitter, the amplifying ratio is equal to the ratio of effective areas of the two bellows. Since the differential pressure transmitter has the same size of bellows, the amplifying factor is less by a value of 1.0, because the measured pressure is not effective on the area of the small bellows.

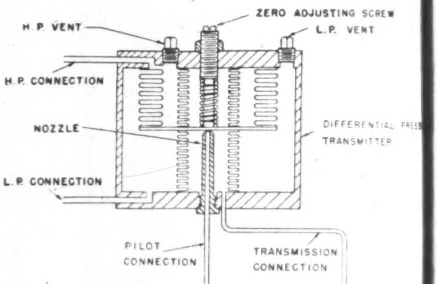

ZERO ADJUSTING SCREW
H.P. VENT
L.P. VENT
H.P. CONNECTION
NOZZLE
DIFFERENTIAL PRESS
TRANSMITTER
L.P. CONNECTION
PILOT CONNECTION
TRANSMISSION CONNECTION

Fig. 6

This system has a useful application, in that it can measure absolute pressures and transmit a gage pressure which is direct-reading in absolute units. This is accomplished by evacuating and sealing the low-pressure side of the differential element and applying the unknown pressure to the high-pressure side. The transmitter then measures the difference between the unknown pressure and absolute zero—this is actually measuring absolute pressure. Since the receiving element and the upper bellows both are subjected to atmospheric pressure, the-gage-pressure receiver is fully compensated for barometric changes and is direct-reading in absolute pressure values.

Within the differential measuring unit, it is rather interesting to note that this simple construction simultaneously subtracts, multiplies, and adds, in terms of pressures, and yet it has only three moving parts which do not touch the pilot nozzle, and move only a fraction of a thousandth of an inch. The measurement across the bellows constitutes the subtraction; the ratio of areas of the bellows constitutes the multiplication; and the spring load (zero adjuster) is responsible for the addition. All these functions are accomplished without the use of pivots, levers, or sliding or contacting members—hence, the instrument is friction-free, and responsive to extremely small changes in the measured variable.

4. Motion Transmitter

Fig. 7 illustrates the use of the same principle to measure motion and transmit a pressure which is directly proportional to this motion. In order to transmit a linear relationship, it becomes necessary to use a spring which, in itself, has linear characteristics. A vertical motion compressing the spring will then be balanced by a directly proportional pressure. The loading spring itself must be mounted so that it is completely friction-free, with the first active coil offset from the dead-end coils to eliminate even the slightest rubbing action between convolutions. This method of motion transmission requires power and is, therefore, suitable only for those applications wherein the motion to be measured is capable of exerting a force, without changing the actual motion.

5. Temperature Transmitter

Fig. 8 shows essentially a pressure transmitter in which the pressure change results from a change in temperature of the gas-filled bulb. Inasmuch as the difference in the effective area of the bellows will result in an amplifying factor, the same thermal element can be used, regardless of the range of temperature measured. The limiting factor is the permissible pressure which can be built up in the system without deforming the bellows of the thermal element. In practice, the same bulb made for −100° to 0°F. can be used for 0° to 200°F. A thermal assembly, made with a lower filling pressure, suitable for a 300° range, can also be used on an 800° range. This means that an extremely high overrange protection is available on low-temperature applications. This becomes quite important with sub-zero temperature ranges, where the bulb assembly may have to withstand 150°F. during shipment, before it is even put into service. These characteristics of the thermal element mean that in itself it has "no range," and that the range is determined by the transmitter. This provides for interchangeability of elements and for stocking only one style of bulb assembly with two different filling pressures, regardless of the range of measurement.

This application of the pneumatic null balance system permits the thermal bellows to remain in essentially the same position for any transmitted pressure. This means that the initial high ratio of bulb-to-bellows volume can be maintained at any temperature. Consequently, the ambient temperature effect can be made negligible, and varies only slightly with the temperature measured.

The zero loading spring illustrated in the diagram is capable of adjusting the range within unusually wide limits. For example: a transmitter designed to operate over the range of −100° to 0°F. can be adjusted by means of this spring alone, to operate over a range of 200° to 300°F. This will cause no change in the span or linearity of response. In practice, the higher-range bulbs are filled to one-half the absolute pressure of the lower-range bulbs, so that a bulb of lower-filling pressure can be interchanged to double the range of the instrument, without altering the transmitter.

Since the characteristics of the gas-filled system are practically linear, the functioning of the thermal element is a matter of the force exerted against the transmission bellows. Therefore, each thermal element can be filled at a pressure which will give the same force change for a given temperature change. This altered filling pressure compensates for any variations in the effective area of the thermal bellows, as manufactured. Inasmuch as the measurement of force is made comparatively, against a master standard, all bulb assemblies are interchangeable and will produce the same force change for a given temperature change.

6. Pressure Regulator

A pressure regulator using the pneumatic null balance principle is capable of maintaining regulated pressures at a constant value, regardless of the variation in upstream pressure or of variations in flow. Fig. 9 illustrates the

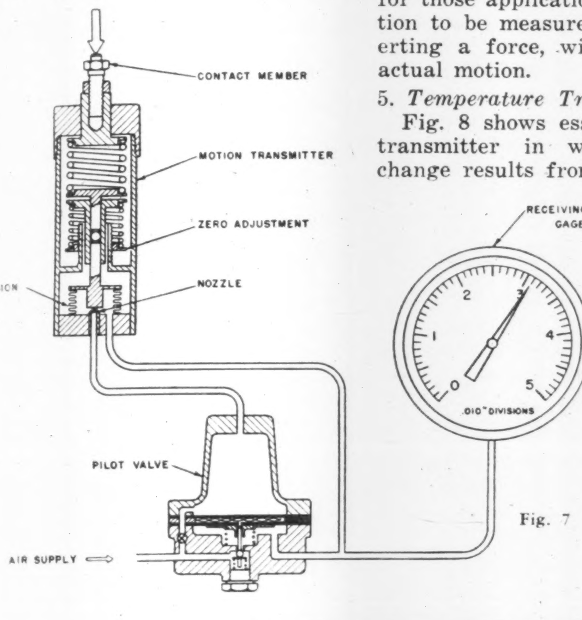

CONTACT MEMBER
MOTION TRANSMITTER
ZERO ADJUSTMENT
TRANSMISSION BELLOWS
NOZZLE
PILOT VALVE
AIR SUPPLY
RECEIVING GAGE
0
1
2
3
4
5
.010" DIVISIONS

Fig. 7

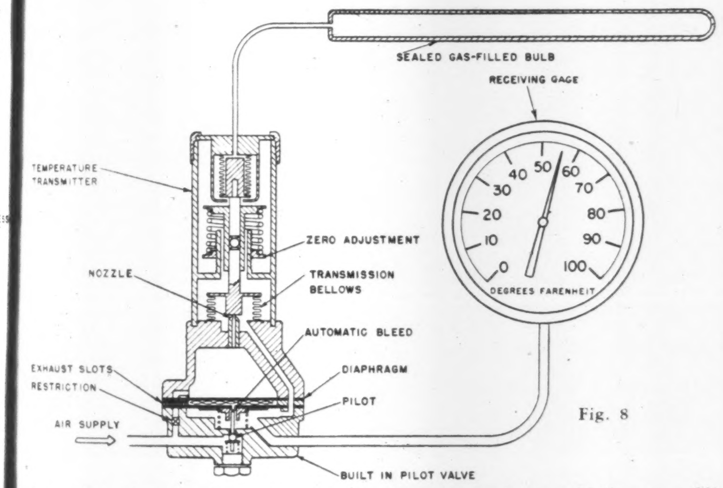

SEALED GAS-FILLED BULB
RECEIVING GAGE
TEMPERATURE TRANSMITTER
ZERO ADJUSTMENT
NOZZLE
TRANSMISSION BELLOWS
AUTOMATIC BLEED
EXHAUST SLOTS
RESTRICTION
DIAPHRAGM
PILOT
AIR SUPPLY
BUILT IN PILOT VALVE
0
10
20
30
40
50
60
70
80
90
100
DEGREES FARENHEIT

Fig. 8

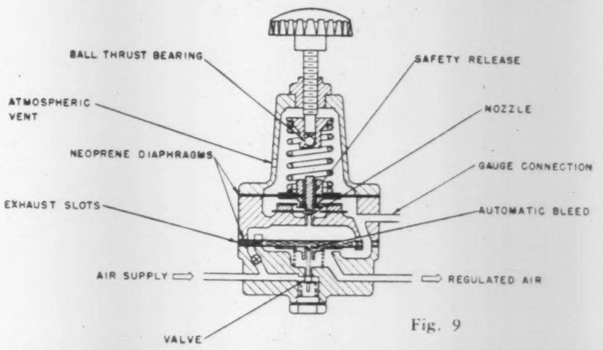

BALL THRUST BEARING
SAFETY RELEASE
ATMOSPHERIC VENT
NOZZLE
NEOPRENE DIAPHRAGMS
GAUGE CONNECTION
EXHAUST SLOTS
AUTOMATIC BLEED
AIR SUPPLY
REGULATED AIR
VALVE

Fig. 9

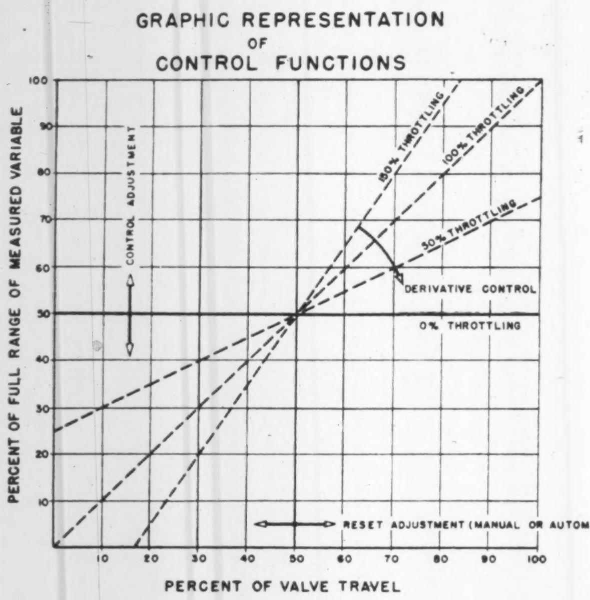


Fig. 10

manner in which this circuit is applied. The total motion of the loading spring for variations in flow is reduced to less than 0.001", as this is the total motion required to operate the pilot nozzle. The pilot air pressure can, therefore, open the main supply port wide, with this slight motion of the loading spring. It is this change in position of the loading spring which causes a non-piloted regulator to decrease in output pressure with an increase in flow. For the same reason, the effect of increased upstream pressure on the area of the diaphragm member is balanced by a slight increase in the pilot-air pressure, resulting in a small motion of the loading spring. It is evident that the circuit of this pressure regulator is the same as the circuit in Fig. 3, except that the regulator has been built as an integral unit, and the measured variable has been replaced by a loading spring.

AUTOMATIC CONTROL

The ultimate purpose in any process is to maintain accurate control of the process variables. Regardless of the accuracy with which measurements are made, unless these measurements can be utilized to control the variables, the full advantages of instrumentation will not be realized. The remainder of this article describes means of applying the pneumatic null balance principle to accomplish all the necessary functions of automatic control.

In order to understand the simultaneous functioning of the various components of the controller, it will be necessary to obtain a mental picture of these functions and their interrelationship. The graph shown in Fig. 10 is an attempt to combine these functions in one picture, so that this relationship can be more clearly understood as a whole. The ordinate has been plotted as full-scale range of measured variable and the abscissa as percent of control-valve travel. The diagonal lines, then, represent the various throttling ranges, or the proportional band of the controller output air. A vertical translation of this family of curves constitutes control-point adjustment. A horizontal displacement corresponds to reset adjustment, which corrects for changes in load (and which may be manual or automatic in its operation).

Much has been written about derivative control, but it is doubtful whether this function has its full significance in relation to the other control functions, when expressed merely as a derivative action. It is obvious that the purpose of such a derivative action is to anticipate deviation from the control-point by introducing a function which is dependent only on speed and direction of the measured variable. This might be described as anticipating the measured variable reaching the control point, by introducing an earlier corrective action; but the purpose of control is to maintain the variable at the control point. Any deviation must be corrected the instant it shows any departure, so that this value will be maintained. Therefore, it would be far simpler to define it as an "automatic throttling range adjustment," instead of referring to this corrective action as derivative control. This is represented in the graph by showing a rotation of the family of throttling-range curves. This rotation takes place about the point of operation of the process variable at that particular instant, and will be dependent only on the speed and direction of the measured variable.

Pneumatic Null Balance Circuit for Obtaining Control.—Fig. 11 diagrammatically illustrates the means of applying the null balance principle to accomplish the functions of control illustrated on the graph, Fig. 10. The entire system works on a balance of pressures without the use of adjustable levers or friction members for operating through the various manual and

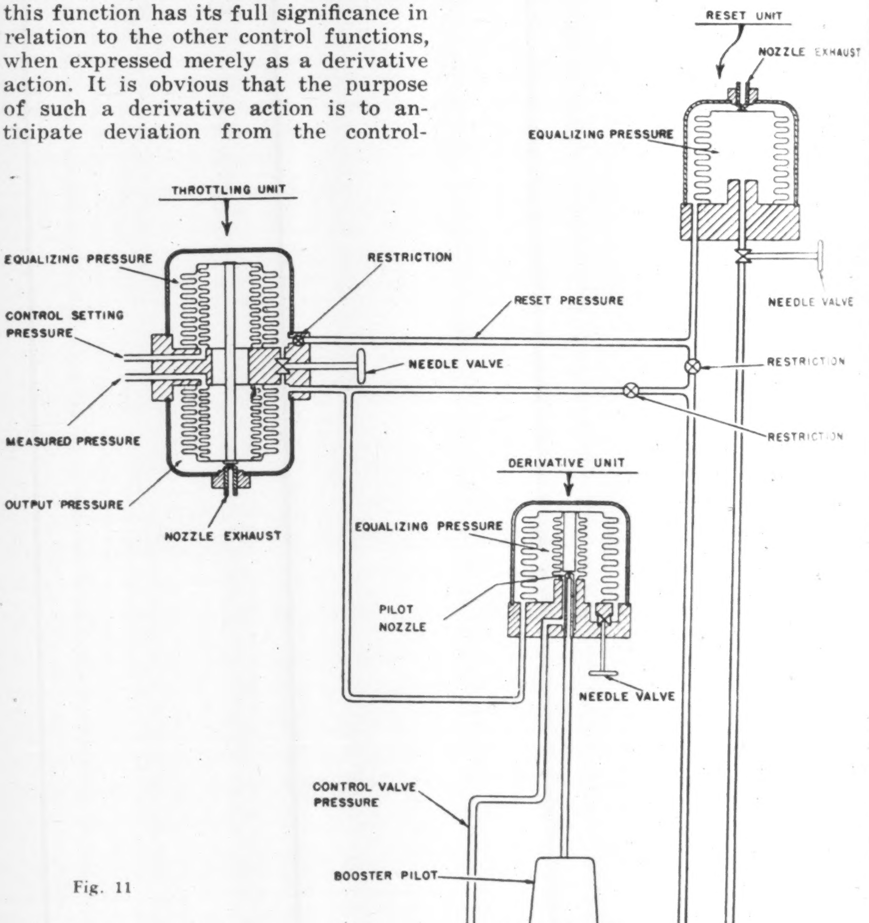


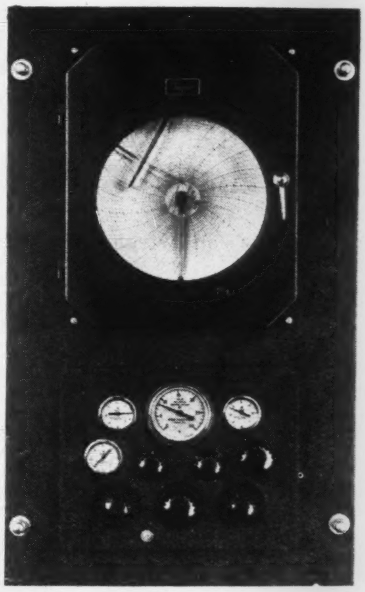
Fig. 11

automatic adjustments. Each unit performs its specific function and, with the exception of the throttling unit, may be eliminated by a re-arrangement of the circuit, if that function is not desired.

Throttling Unit.—In the control circuit illustrated (considered independently of the derivative function) there are actually four main variables. They are: (a) measured variable, (b) control-setting value, (c) control-valve pressure and (d) reset correction. In the illustration shown, these are in the form of pressures and are simultaneously balanced to obtain throttling control. The equalizing pressure, shown in the circuit, is maintained always at a value which is between the throttling-unit-output pressure and the reset pressure. This value is determined by the pressure-dividing action of the needle valve and restriction. An adjustment of the needle valve in the throttling unit will vary the throttling range from practically zero to 100% or higher. This upper limit is dependent on the selection of bellows areas. If the needle valve is closed, the maximum throttling range will be obtained. If wide open, so that no appreciable pressure drop occurs across it, a zero throttling range, or on-off control, will result. Proportionate throttling ranges are obtained by intermediate settings.

The control-setting pressure is obtained by using a pressure regulator which may be set manually, as desired. Transmission of the measured and control setting pressures to the recording or indicating instrument may be made —completely independently of the controller. Hence, bearing friction and pen friction will have no effect on the control functions.

The throttling unit will operate a reverse-acting valve without causing any shift in the system, if the control-setting pressure and the measured pressure are interchanged. This can be readily understood since the four pressures in balance will result in equilibrium conditions.



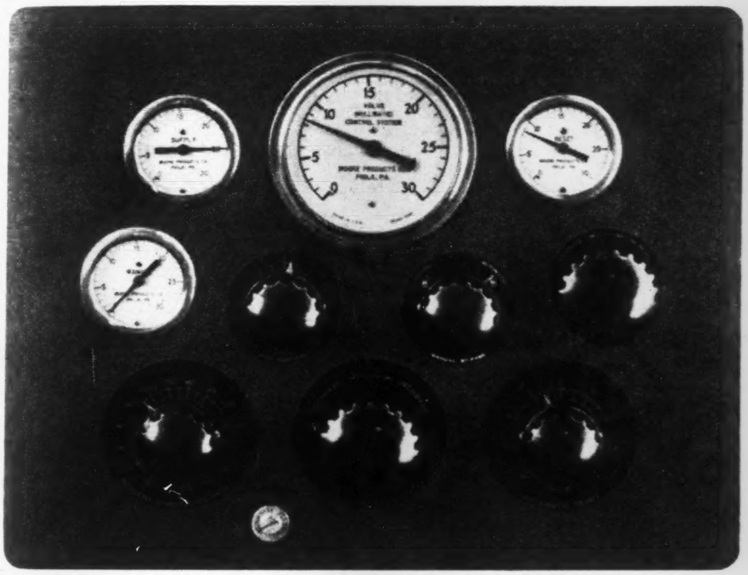


Fig. 12. General view and detail of "Nullmatic" control panel.

Automatic Reset Unit.—Where manual reset is required, a precision regulator, such as is illustrated in Fig. 9, may be used to set the valve at the required position, to suit load conditions. Where automatic reset is necessary for the process control, the null balance system requires a pressure regulator, but uses one which is operated by the control-valve pressure, instead of by a manual adjustment. The needle valve in the reset unit, connected to the control pressure of the diaphragm valve, delays the change of pressure on the inside of the single bellows in accordance with its setting, which is made to suit the requirements for rate-of-reset action. The single bellows acts merely as a 1:1 pressure transmitter, building up a loading pressure of the same magnitude by using the power from a separate source of air supply. This pressure is then transmitted to the throttling unit and serves to change the position of the valve with respect to the measured variable, dependent on the magnitude and elapsed time of departure from the control point. When equilibrium is reached in the system, with the measured variable at the control point, all pressures in the units are equalized and the system is in balance.

Derivative Control Unit.—Any process in which there is a time lag can be benefited by the proper application of a derivative correction which is dependent on the speed and direction of the measured variable. Stability of control is an extremely important factor in many applications and, when process lags are present, it usually is necessary to adjust for a wide throttling range. If satisfactory control can be obtained with a narrow throttling range, the introduction of derivative control can serve no useful purpose, since the throttling range is already adjusted to approximately its minimum value. As has been previously explained, this *temporary* narrowing of the throttling range is essentially the action of a derivative control unit. As shown in Fig. 11, the output of the controller is applied to the outside of the large bellows, utilizing the air supply as a separate source of power. The bleed across the needle valve restores the transmission through the derivative control unit to a 1:1 ratio. The duration of this correction is, therefore, dependent both on the magnitude of the process variable change and the setting of the needle valve. If the change in output pressure from the controller is extremely slow, the bleeding across the needle valve will maintain an equalizing pressure condition. Then it might be said that the output of the controller is transmitted through this unit without any change, other than a transmission in a 1:1 ratio. In other words, any corrective measures introduced by the derivative control unit will either add to the output of the main controller or subtract from it, depending on speed and direction only, and independently of the actual control point.

"Nullmatic" Control System.—The photograph, Fig. 12, shows a complete pneumatic null balance control panel. Since there are no members to cause friction, this panel provides a control system responsive to the slightest changes in the controlled variable. The recording receiver functions entirely independently of the control system and includes a second pen for recording any changes made in the control point.

A by-pass valve and manual regulator are provided so that the process may be swung over to manual control, when necessary. The circuit permits the manual control pressure to be fed back to the reset-pressure line, so that the controller is always synchronized with the process and may be swung back to automatic control at any time. The gages provide a visual picture of the simultaneous action of the throttling, reset, and derivative control functions, with the resultant control valve action.

RADAR INSTRUMENTATION

America's Contribution, with Special Reference to the Bell System: Developments by Bell Telephone Laboratories and Mass Production by Western Electric

By W. M. REYNOLDS, American Telephone & Telegraph Co., New York

IN importance of contribution to victory, radar ranks high in the top bracket of new instruments in World War II. Although British radar instruments were the first to be used effectively, the *development* of radar to its present high level of effectiveness and the *production* of radars in the large quantities required by the United Nations' land, sea and air forces has been an outstanding contribution of the United States to the Allied cause.

During the headlong development of radar instruments since Pearl Harbor, design changes followed one another in rapid succession. Radar was a new instrument being adapted to global war on and over the earth and at sea.

TYPES OF RADARS

Radar instruments are broadly classified in two categories:

First, the "search" type which sweeps wide and distant areas to detect the approximate position of a target;

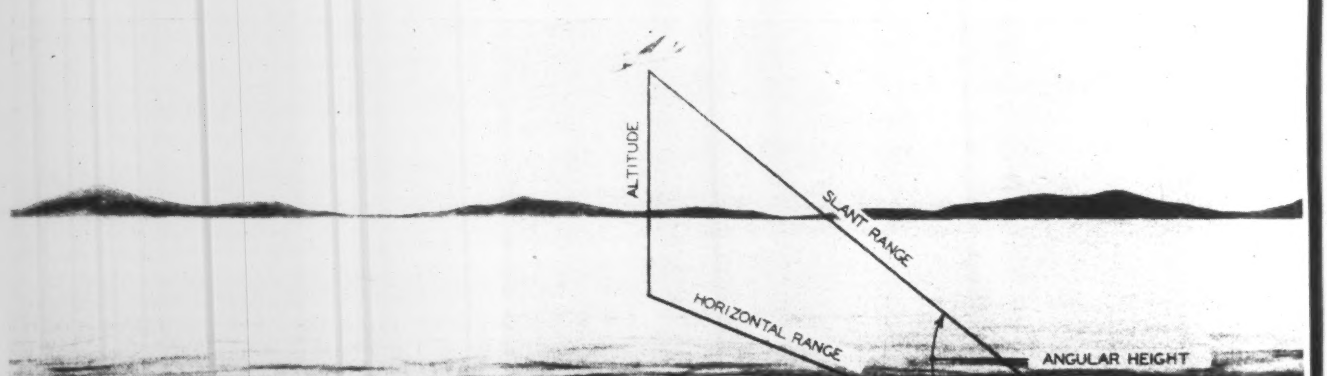
Second, the "fire control" type which uses a narrow beam to determine precisely the position of the target so that shells can be properly aimed or bombs released at the right instant.

The search operation can be compared to scanning the entire scene with the naked eye, while fire control radar is comparable to focusing a telescope to "draw a bead" on the target.

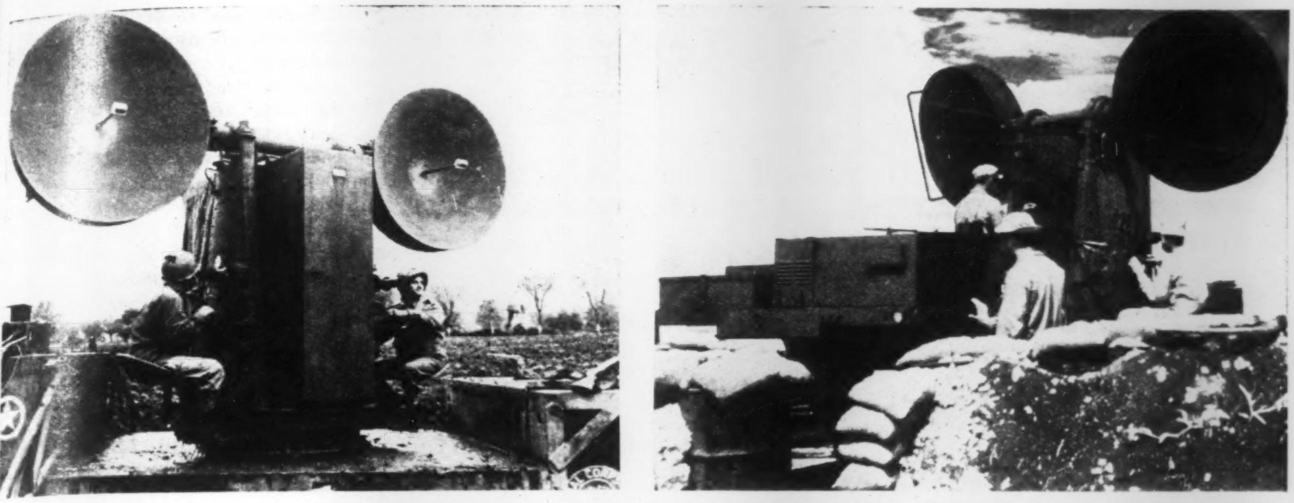
Technological evolution of radar, coupled with experience gained in combat use, constantly pointed the way to new uses and better designs. Altogether, Bell Telephone Laboratories developed and produced designs for about 100 radars.

RADARS IN ACTION

Radar is credited with an important role in enabling the Allies to stand off the aggressor nations during the early years of the war, and to turn the tide against them as we did. An early radar, of the long-range search type, enabled R.A.F. airmen to save Britain from the Nazi air blitz. Without radar, the Allied armies could not have landed so successfully on the European continent, destroyed the Nazi armed might and coped so effectively with the deadly



Radar control of antiaircraft artillery fire. The electrical impulses from the SCR 268 radar are fed to the gun director, which automatically points the guns and makes all corrections, and automatically sets the shell fuses for the correct range and altitude. *(U. S. Army Drawing)*



Another U. S. Army Signal Corps radar is the SCR-547, known as the "Mickey Mouse" because of the shape of its antennas. (LEFT) An SCR-547 maintains watch near an antiaircraft artillery emplacement at Mignano, Italy. (RIGHT) Another SCR-547—somewhat different in its auxiliary instruments—on Espiritu Santos, New Hebrides. (*U. S. Army photographs*)

buzz-bombs. And in the vast spaces of the Pacific Ocean, shipboard and airborne radar instruments have aided our sea and air arms in shattering Japanese ships and planes from Guadalcanal to Okinawa, and in blasting military targets on Nippon's home islands in fair weather and foul.

The effectiveness of radar can be illustrated by citing some of the battle accomplishments of a few of the radars developed by Bell Laboratories and manufactured by Western Electric:

On the Anzio Beachhead in Italy, our troops were taking a pounding from enemy night bombers. A new fire control radar was brought in. The morning after its first night of action the ground was strewn with Nazi planes. Soon the night attacks stopped: the Germans were losing too many planes to make it pay. In the Pacific, too, this radar saw plenty of action: it furnished anti-aircraft protection on Saipan, Leyte, Okinawa and on other islands, particularly during the early days of each invasion.

In the Battle of Santa Cruz Island, the fabulous Battleship X (South Dakota) was credited with bringing down 32 enemy planes in one engagement. It was the Navy's first anti-aircraft fire control radar, designed and built for the Navy by the Bell System, that pointed the guns in this blazing action.

Japanese reaction to the amazing accuracy of U. S. Navy guns in pitch darkness and at great range is shown by this authenticated story: It was a night battle near Guadalcanal; our warships had sunk a number of enemy ships before they could open fire. A Japanese officer, fished out of the water, asked immediately to see what he called "your six-inch machine gun with the electric eye pointer."

CREDIT SHARED BY MANY

Like a tree, radar has grown from many roots. Many years before the war a group under the immediate direction of Dr. A. H. Taylor and Mr. L. C. Young and their associates in the Naval Research Laboratory and the staff of Colonel (now Major General) R. B. Colton of the Signal Corps were experimenting with early forms of the radar principle. In Great Britain Sir Robert A. Watson-Watt and his associates were experimenting along similar lines at the same time. Thus, radar has been developed through years of research and experiment, chiefly in the United States and Great Britain. Credit must be shared by many of the foremost scientists of the two nations, both civil and military.

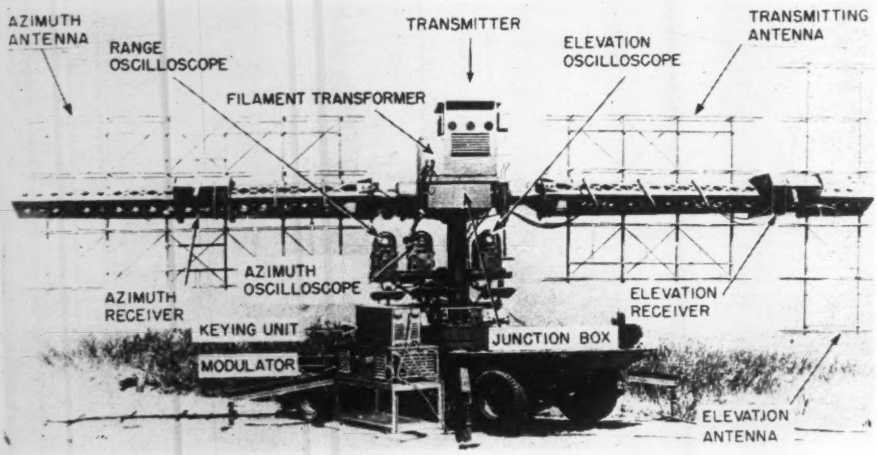
LIGHT AND COMPACT. Paratrooper about to jump with a special type of radar, which is used by the advance paratroop units as "ground beacon" for troop carrier planes. Latest models are lighter and even more compact than the one shown. (*Acme Photo, from AT&T*)

At all stages of the development of radar, the techniques of the communication art have been drawn upon by the scientists and engineers. It is natural, therefore, that Bell Laboratories should have been giving attention to this problem before the outbreak of the war in Europe in 1939. Since that time the Laboratories have worked closely with Army and Navy specialists, with scientists in Great Britain, and with the National Defense Research Committee. This committee set up the Radiation Laboratory at Massachusetts Institute of Technology in November 1940 to carry on research and development work in radar. Reciprocal disclosures have been made by American and British scientists. In fact the wartime radar development program has furnished an outstanding example of coöperation, both internationally and between private and government enterprise in this country.

This country has been in a position of leadership among the United Nations in research, development, and production of radars for use in every phase of modern warfare. To such wartime leadership the Bell System's extensive research and manufacturing organizations, the Bell Telephone Laboratories and the Western Electric Co., made outstanding contributions. Together they have formed the Number One industrial team in radar technology and manufacture. This is borne out by the following facts:

Bell Telephone Laboratories has had a much larger group of scientists and engineers than any other industrial organization working throughout the war in advancing radar science and in designing new radars for the Army and Navy. Not only have more radar designs come from these Laboratories than from any other industrial laboratory, but also a much larger volume of completely new and essential components has been developed there.

The Western Electric Co., with the aid of hundreds of sub-contractors to which it supplied specifications and manufacturing procedures, has sup-



Labels identify the various components in this broadside view of the SCR-268. (*U.S. Army Photo*)

Close-up of an SCR-268 radar in Italy. Thousands of these "early warning" instruments were manufactured by Western Electric. (*USA Signal Corps Photo, from AT&T*)

plied more radars—all of them of Bell Laboratories design—than any other manufacturer.

In short, the research and manufacturing branches of the Bell System have together developed and supplied to the Government radars and their components in volume greater than any other supplier.

All large guns of the U. S. Navy are pointed by radars designed by Bell Laboratories and made by Western Electric. Radars designed by Bell Laboratories and made by Western are standard for the B-29's in the Pacific for navigation, target location and high-altitude bombing. The Bell System team has also developed and produced the low-altitude radar bombsights for attacks against enemy shipping that have had largest use by the Army and Navy.

Bell Laboratories pioneered in research on electrical computing portions of the radar bombsight and has been responsible for the development of most of those that have had large combat use. Bell scientists have shared almost the entire research and development programs of the bombing radars with the Radiation Laboratory of the National Defense Research Committee whose staff of scientists and engineers devoted to radar has been of about the same size as that working in this field at Bell Laboratories.

Much of the bombing problem is made automatic by a new type of computer developed by Bell Laboratories. Most of the necessary information can be "set in" the equipment before the target is reached. Except for one simple operation, the instrument does the thinking and acting" under fire over the target. The computer supplies the automatic pilot with complete information to steer the plane and the computer automatically drops the bombs at the release point. Still more accurate radar bombsight systems are in process of development.

Up to June 30, 1945, Western Electric had supplied the government with 52,930 radar systems of *sixty-four different types,* valued at more than $800,000,000.

Bell Laboratories in 1944 was at work on *eighty-one different types* of radar systems.

The above figures on development and production of radars mean a great deal more when the nature of the undertaking is considered. Radar is an intricate structure of vacuum tubes, transformers, electrical networks, rheostats, capacitors and many other classes of circuit elements interconnected by wires and coaxial conductors or wave guides.

Each type of radar is designed and built for a specific purpose. One radar may have over 370 vacuum tubes, another only 80. (By comparison, a moderate-sized, console-model radio for home use may have eight tubes.) A land-based radar may weigh [illegible],000 pounds, while smaller, compact units built for fighter planes tip the scales at only about as much as the pilot.

A radar may cost $87,000 or $6,000. It may require 40,000 labor hours to complete, or only about one-tenth as long, depending upon its size and the purpose it is to serve.

The Bell System's contribution to radar's development and production has grown from the same roots that produced and continue to nourish our nation-wide telephone system. It is natural, therefore, that electronic and transmission devices developed over the years in the extension and improvement of Bell System services have been drawn upon freely in producing radar. While the fundamental principles of radar have been developed in a number of places, continuous research in high-frequency electric waves by the people of Bell Telephone Laboratories has resulted in a number of fundamental electrical equipments now utilized in radar. Examples:

Radio communication was given its first great impetus by de Forest's audion tube, and particularly by the development of the audion into the *high-vacuum tube* by Bell scientists in 1913. This latter achievement resulted in the first transoceanic telephone demonstration by the Bell System in 1915. Today, the Western Electric Company is the largest producer of the new types of vacuum tubes around which all radar systems are built.

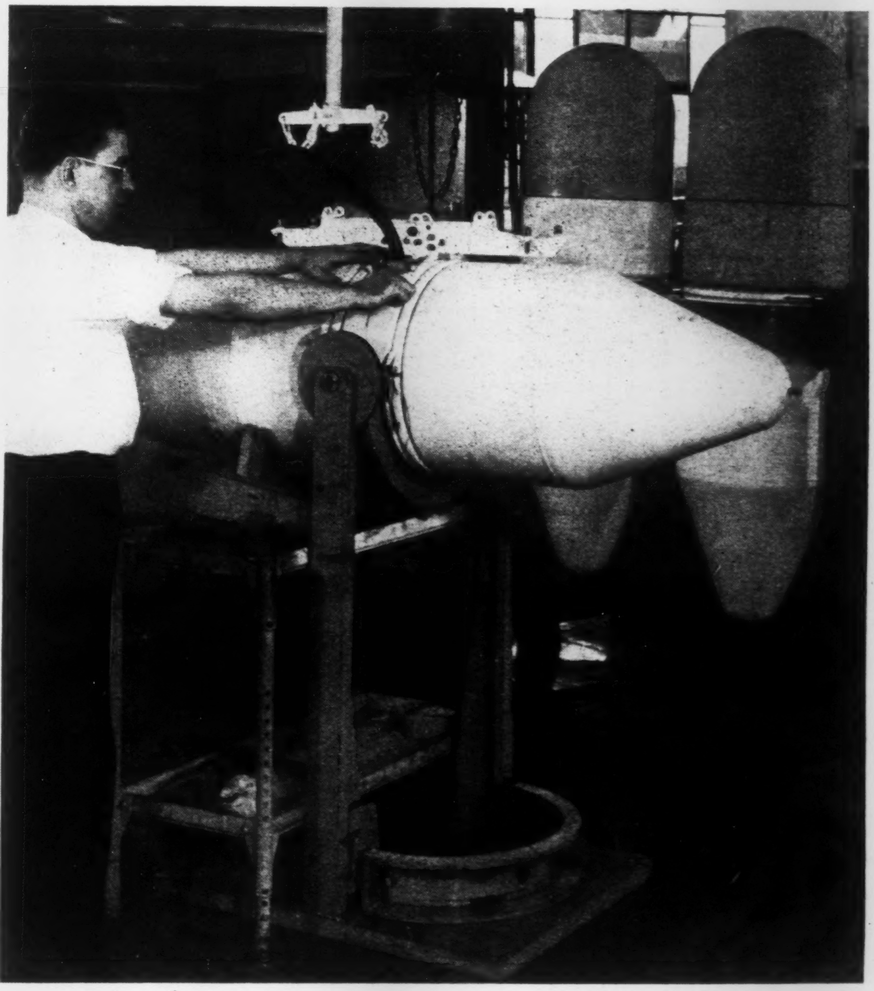
Invention of the *electrical wave filter* in the early 1900's by which waves of a given length are allowed to pass and all others are screened out, was another Bell System contribution. This was a major step toward the control of high-frequency waves, and it made possible "carrier" or multiplex telephony—the simultaneous transmission of several messages at different frequencies over the same line.

With the high vacuum tube and the wave filter available, Bell scientists went ahead with extensive developments in high-frequency transmission. By the end of World War I, they had devised (a) The first airplane-to-ground radio system; (b) The first commercial "carrier" telephone system; (c) The first ship-to-shore radiotelephone system.

Since the early years of the century, intensive Bell System research had been directed at radio transmission over a wide range of frequencies. As part of this work, short pulses of high-frequency waves were used to *measure the altitude of reflecting layers in the stratosphere* (ionosphere), just as a mariner sometimes used an echo of a ship's whistle to establish his distance from a cliff. To record and time these reflected waves, a *cathode-ray tube* was employed in the circuit—a method now widely used in radar.

In the middle 1920's, the Laboratories invented the *absolute altimeter* (terrain clearance indicator) which employed the principle of shooting radio waves against the ground and timing

"Thinking cap" of PT boats, this "radome" bulb houses the antenna of the radar set aboard the vessel, protecting it from the corrosive action of salt water spray. Of great importance to the PT's, since much of their work is under cover of darkness, radar's eye pierces the night, indicates targets, warns of navigational dangers. (*Acme Photo from AT&T*)

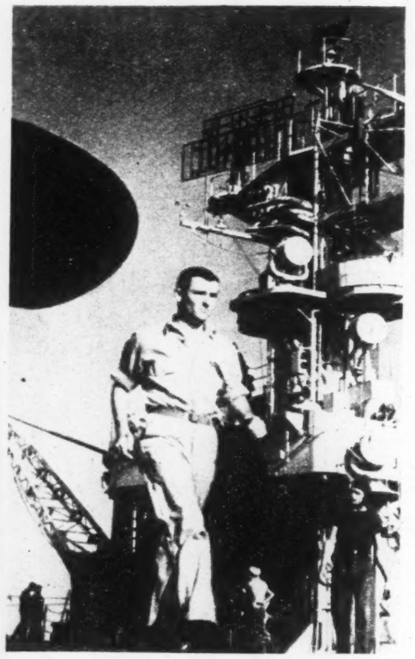


Attached to the wings of Navy carrier-based planes, this type of radar, manufactured at Western Electric's Hawthorne Plant in Chicago, has a bomb-like plastic case which reduces wind resistance and protects the equipment from the elements. (*AT&T Photo*) their return to the airplane. This assumed commercial form a decade later.

Bell Laboratories pioneered the development of *very short-wave tubes.* These made possible the introduction of the altimeter in the 1930's. About 1938, these tubes were ready for the first radar experiments made by the Laboratories in coöperation with the Government. Further developments of high-frequency tubes followed, and with the war came the Laboratories' famous 6AK5 tube which amplifies reflected radar signals in nearly all U. S. radars.

About the same time the altimeter was introduced, another Bell Laboratories engineer used a modification of the altimeter in a series of experiments at 15th Street in Brooklyn, overlooking the Narrows leading into New York's upper bay. With his apparatus enclosed in a directional antenna, he observed that *radio waves directed at ships* passing through the Narrows were thrown back into the receivers.

Conductors that would effectively transmit high-frequency waves were essential in general communication work, as they are in radar today. In the 1920's Bell Laboratories developed the *coaxial cable system* which used high frequencies to multiply the number of telephone messages that can be sent simultaneously over a pair of conductors. Coaxial conductors are widely used in radar circuits.



Radar antennae of varying types crowned the mastheads of our ships, both large and small. Here the trellis-work of this ship's radar antenna looms against the sky. (*Acme Photo, from AT&T*)

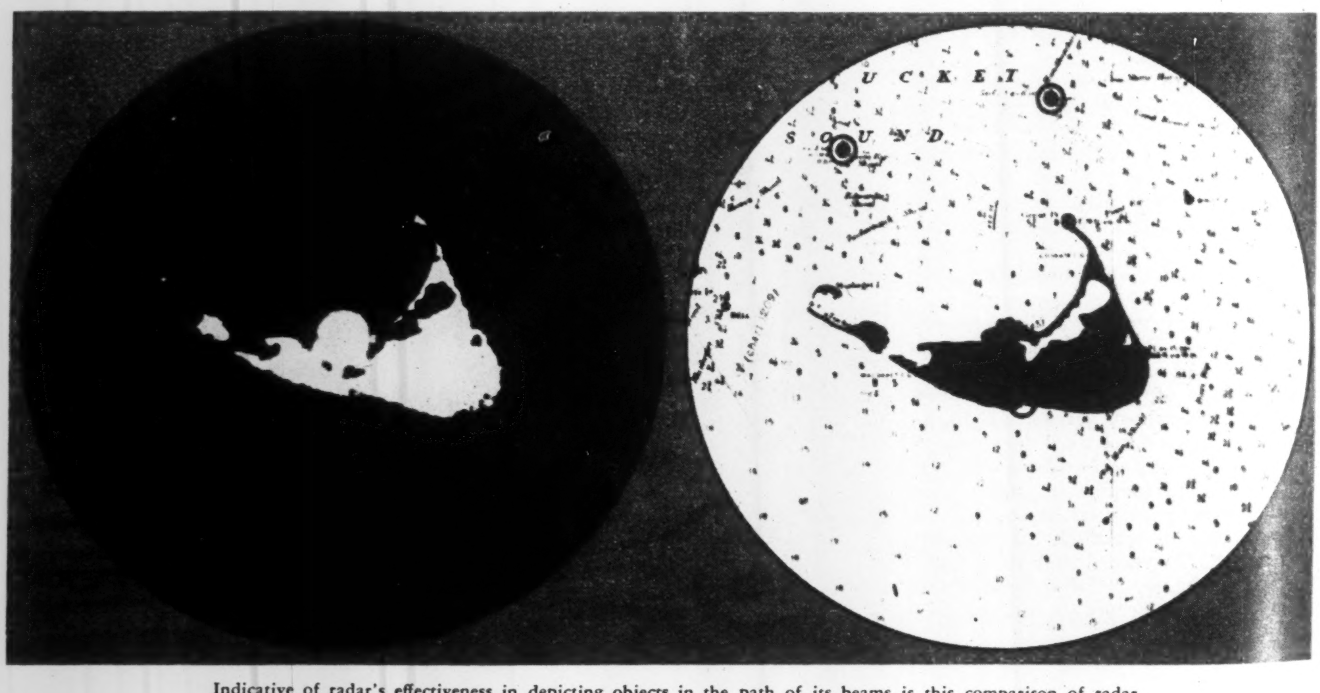
Studies of transmission structures for still higher frequencies led to development of the *wave guide,* a scientifically-proportioned metal tube through which the micro-waves are piped. For at least a decade before the war, Bell scientists experimented with this device, and by the mid-1930's they had made important discoveries in the new art which were immediately applicable to radar.

In the field of radiating structures, Bell Laboratories has made important contributions, particularly in the realm of directional antennas employed in high-frequency transmission. Outstanding were the *horizontal rhombic antenna* (late 1920's) whose wires are arranged in the shape of a diamond, and the *Musa* (Multiple Unit Steerable Antenna), which not only confines reception to a narrow beam, but also controls the direction of reception.

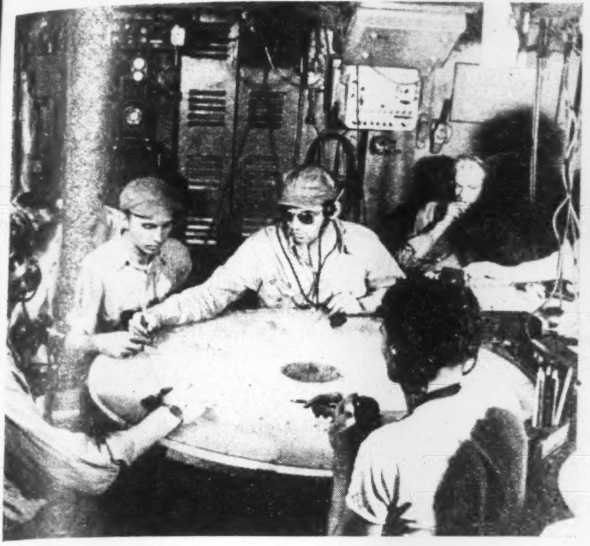
All of the foregoing developments, and many more, were products of telephone research over the years. It was because Bell scientists had this extensive background in high-frequency manipulation, and because Western Electric had made continuous progress in manufacturing devices for high-frequency radio, that such a large proportion of the Government radar projects was allotted to them.

So great was the combined weight of Army and Navy radar production problems assigned to Western Electric that its main plants at Kearny, N. J., Point Breeze, Md., and Chicago could not carry the load along with the company's other war communications commitments. Thus, Western began early in the war to lay plans for enlarging its manufacturing facilities.

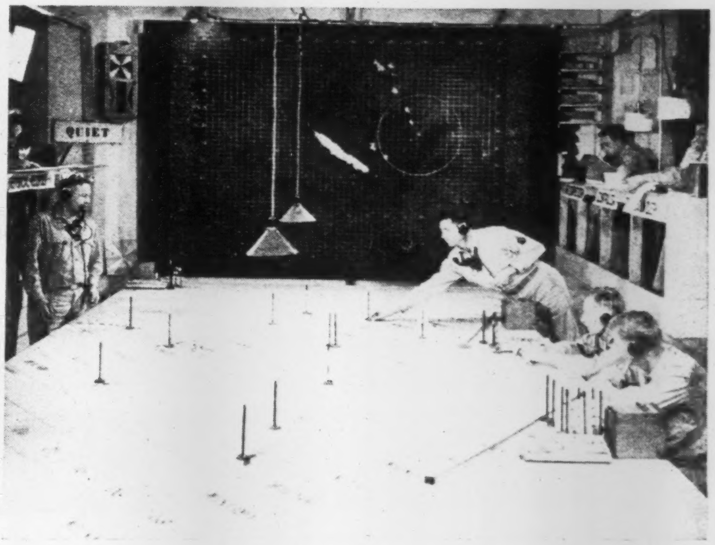
With construction of new plants out of the question, the company concentrated on leasing existing properties in areas where manpower, transportation and other considerations were more favorably. Within a few months a shoe factory in Haverhill, Mass., was turned into a coil winding shop employing 2,000 persons and now turning out radar transformers and other high-priority items. A laundry in Jersey City was changed speedily into a radar assembly shop. In Eau Claire, Wis., Western Electric engineers revamped an ordnance plant, and in Baltimore an airplane hangar resounded to the whirr of



Indicative of radar's effectiveness in depicting objects in the path of its beams is this comparison of radar 'scope photo of Nantucket (left) and an actual chart of the island. On the radar screen, land areas appear white, water appears black, aircraft or shipping appear as white dots. Identification is made by comparison with charts or previous radar photos. Brilliant area in center of radar 'scope photo indicates position of plane from which picture was taken. (*Acme Photo from AT&T*)



In the radar plotting room aboard an Essex-class aircraft carrier, the plotting officer receives reports from the radar officer and translates them onto the large detailed chart before him. This photograph was taken during the China Sea operations in December 1944. *(British Combine photo, from AT&T)*



A complicated system of recording and coördinating the reports from many scattered radar sets has been evolved by the Signal Corps to provide maximum protection against enemy air attack. This plotting board serves an aircraft warning information center at First Island Command Headquarters, Noumea. *(U. S. Army Photo)*

drills and air-driven screwdrivers in the radar production line.

Almost overnight, several floors of a huge Manhattan garage became the world's largest radar assembly plant. Its floor space was equal to six football fields. To get this big plant into production quickly was most urgent, because it was to turn out radar equipment for B-29 bombers, and the development of the planes themselves was well under way when Western got its go-ahead. In rapid order, machinery and utility services were installed, and workers were recruited and trained into an effective production team. It was so effective that not one B-29 had to wait for its radar unit.

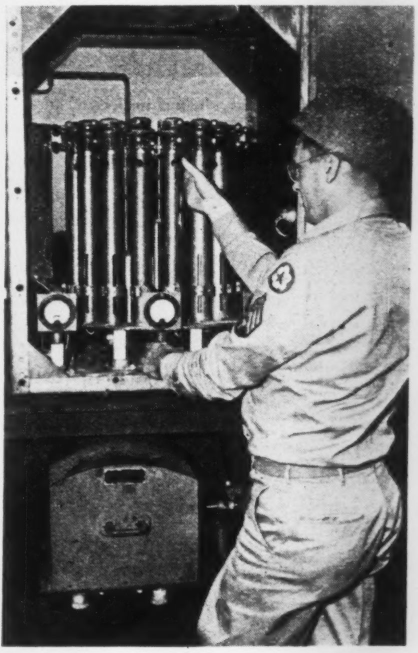
In all, Western set up sixteen shops in nine cities to assist its main plants in turning out the land, sea and air radars. By the last quarter of 1944, more than 40 percent of the company's personnel was engaged in the manufacture of all types of radar.

SUB-CONTRACTING PROGRAM

Western Electric's wartime role was shaped in Washington in 1940 amid intensive study of defense plans. The company became the principal prime contractor and pioneer manufacturer of most of the radar, secret electronic devices and other war communication equipment then in process of development within Bell Telephone Laboratories.

Western Electric also fostered a national sub-contracting program aimed at mobilizing the electronics industry and a large section of the country's unrelated industrial resources to meet the Government's huge requirements in this field.

As the program got under way and the Government requirements mounted, it became necessary for Western to train its sub-contractors in virtually every phase of its own technique. A Western Electric engineer, for example, became the temporary foreman of one sub-contractor's plant. In another plant, 11 Western employees were on duty at the same time, supervising technical methods, quality and assembly controls, expediting and generally helping the sub-contractor to meet his commitments. Often, the engineers of these outside organizations were brought into Western's plants for training. In many instances, Western helped design, and usually financed, the new tools needed by sub-contractors. Also, the company frequently furnished critical materials to sub-contractors.



Radar tube development was a major triumph. Here are shown the transmitting tubes of a mobile field unit for antiaircraft fire control. *(Acme Photo, from AT&T)*

RADAR TROUBLESHOOTERS ON THE FIRING LINE

Without skilled civilian technicians and trained military personnel to keep radar equipment functioning at top efficiency and to fix it if it goes wrong, this great technical weapon would have been far less potent. Here is a Bell System contribution that has taken three forms:

(1) Training military personnel to operate and maintain the equipment,

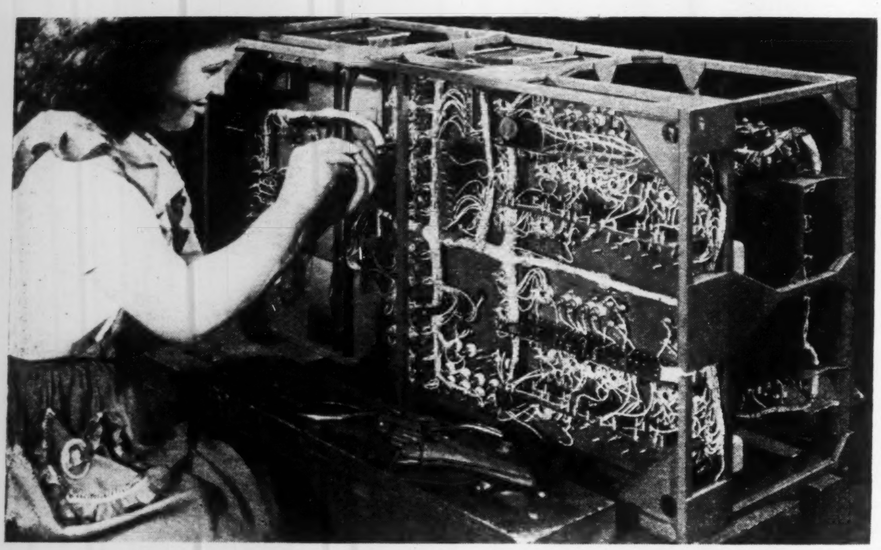
(2) Furnishing detailed and illustrated instruction manuals with each radar unit, and

(3) Supplying the armed forces with field engineers in the various war theaters.

The School for War Training, conducted by Bell Telephone Laboratories in New York City, has instructed some 4,000 officers and men of the Army and Navy. In the aggregate they studied more than 100 courses in military electronics, chiefly radar. After graduation, most of the trainees became responsible for the training of additional men, either as instructors or as officers in command of maintenance units. Many went directly from the Laboratories' school to critical locations. The Navy now requires that every major combat vessel shall carry at least one graduate of the Bell Laboratories' course on radar fire control equipment.

Not only has Bell Laboratories furnished textbooks for its School for War Training, but it also has compiled and published instruction manuals in large quantities, to go along with each radar system. As a result, the Laboratories ranks as one of the largest wartime publishers in America, both for size of printings and number of titles.

As the Navy expanded more engineers were needed. A nation-wide search was made for men with electronic and radio background. Thousands were con-



SYNCHRO STEP CONVERTER, which feeds electrical data from primary radar instruments for operating searchlight controls, in wiring assembly at a Western Electric plant. *(AT&T Photo)*

STEP-BY-STEP CONVERTERS, for Marine Corps ground radar, being inspected at Western Electric's Point Breeze plant. *(AT&T Photo)*

FOR NAVY'S BATTLEWAGONS. The highly-developed radars being assembled at Western Electric's Hawthorne plant are described by the Navy as "the best radar equipment yet installed aboard ship." *(AT&T Photo)*

sidered, and from them more than 500 men of the present field force were selected and trained at Bell Laboratories.

In 1942, the Army Air Forces followed the Navy in asking for similar assistance. Today, Western Electric field engineers are serving with the Navy's Bureau of Ordnance and Aeronautics, the Marine Corps, the Air Technical Service Command, the Signal Corps and the Ground Forces. Their intimate knowledge of the equipment and its possibilities, plus their receipt of the latest technical information, improves the performance and effectiveness of radar. They also send back information from the war theaters to the Laboratories and shops for possible improvement and modification of radars under development.

RADAR TEST SETS

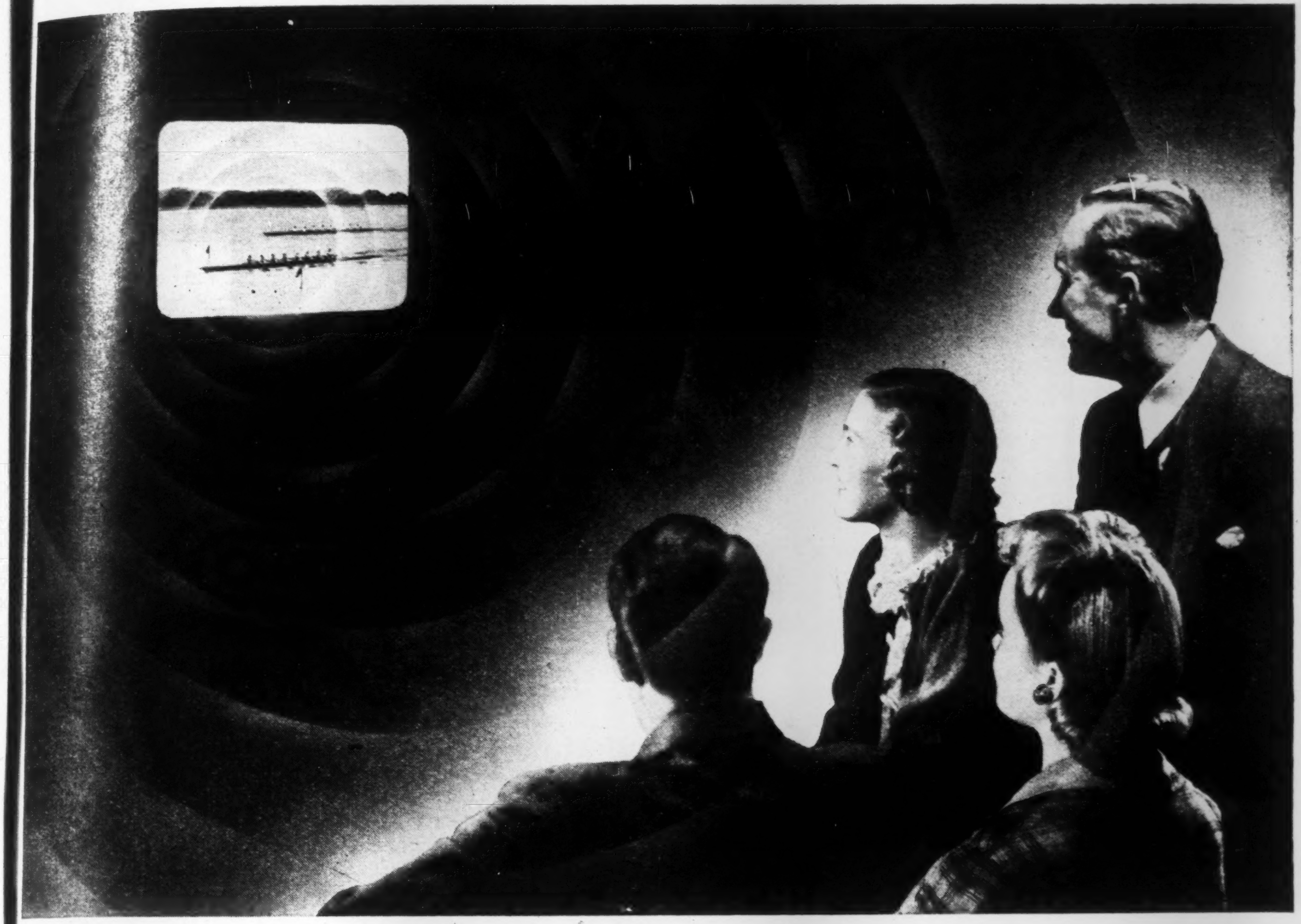
Precision test equipment is vitally important to the proper functioning of radar units. If no objects are perceived on the radar screen, it may mean one of two things: (1) that no objects are within the field of "vision," or (2) that the radar is not working. Only a test can tell which condition exists. Even if one or more objects appear on the screen, only a test can determine whether a better adjustment would make it possible to detect more distant objects. Facilities for testing the equipment regularly are obviously important in keeping it working at best efficiency.

Long before Pearl Harbor, Bell Laboratories undertook to provide test equipment for a few early radars. Commitments grew until the Laboratories assumed a major role in the entire development program and Western Electric a major share of the manufacturing load. The Laboratories developed *more than one hundred different test sets* for different purposes. In 1944 Western Electric made more than 40,000 units of 68 types, substantially all for use by our fighting forces at the war fronts or in their maintenance depots.

These test sets are more exact, precise and intricate than the radars themselves. Some of them are no larger than a loaf of bread. At the same time, since they must be used by troops right at the scene of action at the front, it is necessary that they be rugged and capable of withstanding airplane vibration, shock of gun-fire on shipboard, and the roughest ground transportation.

Radar test equipment developed by Bell Laboratories is used by at least a dozen other government contractors engaged in radar manufacture.

The Bell System's contribution to radar has been made possible by long dedication to the cause of better communication—a cause for which it maintains the largest industrial laboratories in the world and a manufacturing branch geared to serve a nation-wide telephone system—all supported by the savings of many investors entrusted to men and women of the Bell System equally dedicated to the improvement and extension of communication service.



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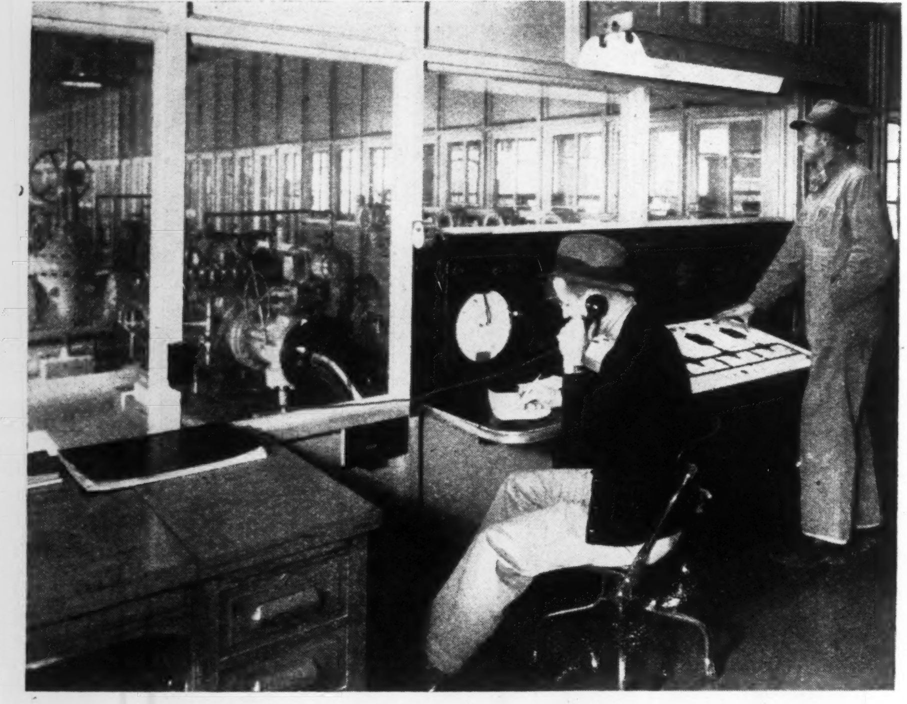

Fig. 1. Station Chief and operator at station control desk.

Electrical Control Features of the Big Inch Pipe Lines*

By MERRITT A. HYDE, Petroleum Engineer, Industry Engineering, Westinghouse Electric Corp., East Pittsburgh, Pa.

FOR more than a year America has had a long-range weapon that is by far the largest of its kind: a double-barreled gun. One barrel is two feet in diameter and 1400 miles long. It's called the Big Inch Pipe Line, and it shoots a stream of crude oil some 313,000 barrels per day, from the great producing area in the Southwest, to the refineries on the Eastern Seaboard. The second barrel, 20″ in diameter and therefore known as little Big Inch, spews about 225,000 barrels per day of gasoline from the refineries of the Gulf Coast to New York Harbor, a distance of 1600 miles.

The refineries of the United States are turning out daily over 500,000 barrels of aviation fuel of 100 octane and better, not counting the many thousands of barrels of lower grades; and the total refinery runs are now at the unprecedented rate of 4.7 million barrels daily. It is a big transportation job to bring enough crude oil to the refineries for this level of activity—but that's only part of the story. It's an even bigger job to deliver the refined products to the far-flung military operations and to essential civilian use.

In the performance of this task, the largest single link is the operation known as War Emergency Pipelines, Inc., whose "Big Inch" and "Little Big Inch" lines cross the eastern half of the United States. These lines are working every day and every night, in unspectacular but effective fashion to deliver, each 24 hours, more than a half million barrels of petroleum and products to the east coast.

To visualize that much oil, think of a train of 100 tank cars, and then imagine one such train heading eastward every hour on the hour, day and night around the clock.

It is but a year ago April that the 20″ line began delivering products to the Linden, New Jersey terminal, yet already these lines have transported a total of some 250,000,000 barrels of petroleum and products. And so, with the excitement of construction now well behind, the project has settled down to a performance proving that it really is a monument to the coöperation of the Oil Industry with the Government to win the war.

Much has been written and spoken about the planning and building of these lines, a feat that has made Big Inch another American by-word of construction accomplishment. But for engineers, there is a special interest in what makes them go.

Consider first "Big Inch." It is a 1400-mile underground conduit, 24″ in diameter for 1,264 miles of its length, from Longview, Texas, to Phoenixville, Pa. There it forks into two 20″ lines, one to the Philadelphia area, totalling some 40 pipe miles, the other about 90 miles to the New York area. The route encounters all varieties of terrain, ranging from the Mississippi bottoms to the ridges of the Alleghenies. Between an elevation of about 300 feet at Longview and sea level at its eastern terminals, its highest point is the 2900-foot Laurel Hill crossing, in Pennsylvania.

Operating at capacity, the line carries a continuous 1,400-mile column of oil, more than 4,000,000 barrels of it, weighing 600,000 tons, moving at a speed of about 4¼ miles per hour. To accomplish this requires a total propelling force equivalent to about 4000 tons. This force and rate of motion represents the expenditure of nearly 100,000 horsepower, by that measure one of man's greatest pumping jobs.

The task is performed by electrically-driven centrifugal pumps. The aggregate installed motor capacity applied to mainline pumping is approximately 120,000 horsepower, in 80 units of 1,500 horsepower each, in 26 stations at intervals averaging about 52 miles, with generally three units per station. Additional spare and auxiliary units bring the total installed horsepower to about 130,000.

Even in these days of big numbers, the installation of 130,000 horsepower of motors in a pumping plant is something unusual. Such a plant would tax the full capacity of TVA's Norris Dam generating station. However, the real interest in this project is not in its size, but in the nature of its operation. It is one thing to build a 130,000 horsepower pumping plant on some particular site. It is quite another matter to set up the same capacity in 26 separate stations performing a single pumping operation, yet extended over a 1,400-mile strip of ground.

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*From a talk before the Michigan Section of the American Institute of Electrical Engineers.

Now the whole character of pipe-line operation stems from subdivision into stations separated geographically but joined physically. The use of a number of stations along the line instead of one station at the origin is dictated, of course, by the necessity of limiting the station delivery pressure to a value that develops a piping stress within the allowable limit.

Considering the section of line between Longview and Phoenixville, if the pumping capacity could be combined into one station at Longview, delivering 300,000 barrels per day through 1264 miles of 24" pipe, with a pressure drop per mile of 12 lbs./in.^{2} and against a static head of 50 lbs./in.^{2} owing to net difference in the two station elevations, then Longview station would have to operate with a discharge pressure of 15,250 lbs./in.^{2}. Of course, this is an impractical condition from the standpoint of pipe design alone. But by dividing the job among 24 stations along this section of the line, the average net pressure developed at each station becomes about 635 lbs./in.^{2}. Allowing for a suction pressure at each station of 50 lbs./in.^{2}, the station discharge pressure would be 685 lbs./in.^{2}. In actual operation, capacity flow is somewhat higher than the 300,000 barrels per day nominal rating of the line, and the net input pressure at each station is in the neighborhood of 675 lbs./in.^{2}. With a suction pressure of 50 lbs./in.^{2}, this means a maximum line pressure at the station discharge of 725 lbs./in.^{2}, a practical value with respect to pipe design.

The average spacing for 24 stations over this 1264 miles of line is 52.5 miles. Actually distances between stations vary from 31 to 78 miles, the spacing being closer for uphill and wider for downhill terrain. In each case the spacing is such that the pressure increment developed by the station is equaled by the static-head difference between that station and the succeeding station, plus the friction drop at capacity flow for the length of piping between the two stations.

For a given capacity, fluid condition and pipe condition, the friction pressure drop per mile is fixed. For interchangeability of pumping equipment it is desirable to maintain essentially uniform station input pressures throughout the line. Under these conditions the station sites are determined by the hydraulics of the line, without much flexibility for convenience in other respects. This fact is important in regard to power service; it means that station locations cannot be chosen to facilitate power-service; rather, power-service must be extended to the station sites as they are determined by pipe-line hydraulics.

In the course of 1,400 miles of right-of-way, it is to be expected that a variety of power-service conditions would be encountered. Power is delivered to the station sites by 16 different utility companies. New power line constructions varied from 1/10 mile up to, in one instance, 120 miles of line for serving three station sites. Service voltages range from 22,000 to 110,000 volts. In all stations the bus voltage is 2,300, stepped down from service voltage through one three-phase transformer rated, in general, 3,750 kva. The transformer-substation installation includes primary disconnect switch, lightning arresters and fuses.

From the outdoor substation, power enters the pumping-station switchgear at 2,300 volts. In this switchgear it passes through a main breaker and thence to a bus from which it is tapped to each motor through suitable starting equipment. This starting equipment is of the full-voltage type wherever the power-service facilities are adequate to handle the across-line starting current of the motors, which is about five times the full-load current. The current demand for the station with two units operating at full load and the third unit starting at full voltage, is about 200% of the running current for three units. In 13 of the 26 stations, reduced voltage starting was deemed necessary. The more elaborate starting equipment in these stations reduces the maximum demand during starting to about 150% of the running current for three units.

The torque requirement for acceleration is minimized by starting the pump with suction valve open and discharge valve closed. The static torque is less than 20% and, as the pump accelerates, the load torque increases as the square of the speed, from substantially zero after breakaway to about 45% at full speed with the discharge valve closed. After the unit reaches full speed, the discharge valve is opened, and normal running load follows.

These motors, having pull-out torque about twice full-load torque, can carry the pump at full load through a substantial voltage dip—down to a voltage approximately 70% of normal. Within that range the starting of one unit does not affect appreciably the operation of other units which may be running. This means that for a particular pumping station the choice between across-line starting and reduced-voltage starting is determined by the ability of the power system to handle the starting demand with acceptable voltage service to other power users on the system. Typical full-voltage starting switchgear is shown in Fig. 3.

Each motor control unit provides time-delay undervoltage protection, and also instantaneous short-circuit protection, and locked-rotor protection. Running load protection is provided by a thermal relay which follows closely the heating characteristic of the motor.

The switchgear is of the metal-clad type with vertical-lift breakers, providing the ultimate in safety, interchangeability, and complete factory assembly — outstanding advantages for pipe-line station service. A single spare circuit breaker is interchangeable in all the units.

The motors are of the squirrel-cage induction type. Their ventilation is by air intake at both ends, with discharge through an opening in the top of the motor frame. Each motor is installed with a so-called "top hat" through which the warm discharge air is drawn into a duct and expelled through the roof by a small motor driven blower. Provision is also made for circulation of this air as a means of heating the station in cold weather.

The motor room is completely separated from the pump room by a fire wall, with no communicating doorways, it being necessary to go outside the building when passing from the one room to the other. With this arrangement the motor room is maintained nonhazardous, and the equipment and installation in this room are of conventional type for nonhazardous location.

The pumps are surprisingly compact. They are single-stage, 16 by 12, rated 8,750 g.p.m., 648 feet head, at 1,780 r.p.m. Each pump is equipped with a suction valve and a discharge valve. These are manually operated; the 16" suction valve requires 156 turns for its complete travel and the 12" discharge valve 118 turns.

From the standpoint of electrical devices and wiring, the pump room is a hazardous atmosphere location, made so by normal drainage from the pump glands, by pump-casing venting operations, and by any abnormal leakage that may occur. The push buttons in the pump room for starting and stopping the units are of the explosion type. Likewise the pressure-protective relays, of which more will be said later.

Having examined the component parts of a typical station, let us now consider their coördination and control. The main 24" pipe enters and leaves the station site at a scraper box where dead-end traps are located for the handling of incoming and outgoing scrapers, employed to clean the line. By suitable valve positioning, the stream is detoured around the scraper traps and through the station, where it receives the pressure increment developed by the pumps and resumes its travel along the line. Check valves permit bypassing the individual units or the station.

The starting and normal stopping of the stations and of units within stations are entirely by direction of the dispatcher, who is located in the headquarters office at Cincinnati. Continuous intercommunication between the dispatching office and all stations is provided by telephone with loud-speaker to permit conversation between the dispatcher and all operators.

Here electrical control performs a superior job, for the operator has at a central location in the pump room, grouped with the principal pressure gages the three push buttons controlling the pump units. So, in prompt compli-

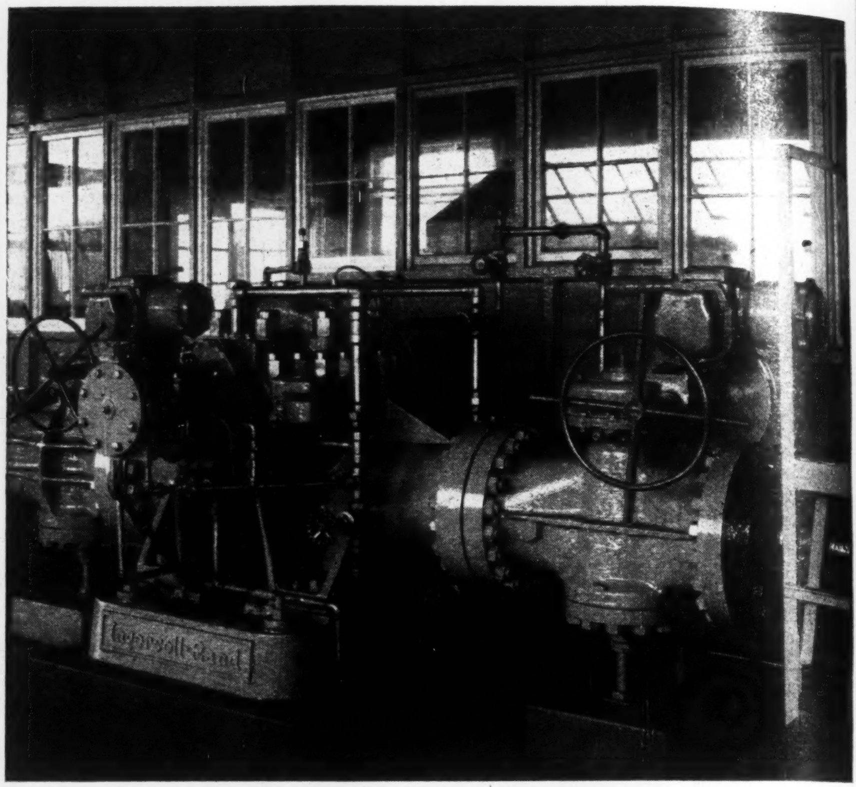

Fig. 2. A single "start-stop" pushbutton controls this complete pumping unit. Suction and discharge valves of each pump are motor-operated. Valve motor control and pump motor control function automatically in proper sequence for starting up and shutting down. Indicating lights on desktop (see Fig. 1) show valve positions and illuminated arrows show course of stream through station piping.

ance with the dispatcher's instructions and without having to lift his glance from a gage, he can operate a push-button to start or stop each unit. When starting up, the pump is up to speed within ten seconds and ready for its discharge valve to be opened. Flexibility and speed in starting and stopping are important contributions by electrical control to the operation of the line.

Of still more importance is the adaptability of electrical control to protective shutdown functions. As already indicated, it is necessary at all times to hold the operating pressures between definite limits of low suction and high discharge pressures.

Low suction pressure permits vaporization of the liquid in the pump casing, followed quickly by possible damage to the pump through gland heating and unbalance. To guard against this, a relay is provided, having a pressure element connected to the station suction. Its contacts sound an alarm at about 35 lbs./in.^{2}, thus warning the operator, who may be able to correct conditions by throttling adjustment. Failing this, a second low-pressure relay functions at about 20 lbs./in.^{2} to cause shutdown. Both of these devices are adjustable to higher or lower settings.

To prevent unnecessary shut-down of the full station capacity, this shut-down relay is arranged to stop the units in timed sequence, beginning with the down-stream unit, with an interval of about five seconds between shutdowns. If upon shutting down a unit, the station suction pressure rises above the reset point of the protective relay, the remaining units are allowed to continue in operation. However, if the suction pressure persists below the protective-relay setting, the remaining units are stopped automatically in sequence at five-second intervals.

Protection against excessively high line pressure at the station discharge is provided by a pressure-actuated relay, similar to the low-suction-pressure relay, and set to function when pressure exceeds about 750 lbs./in.^{2}. For additional protection of station equipment and piping, a pressure relay between unit 2 and unit 3 will allow a pressure at this point not more than 300 lbs./in.^{2} above normal discharge pressure of unit 2. This high-pressure protective relay also will shut down successive units in timed sequence.

In event of a protective shutdown due to abnormal pressure, the operator may have difficulty in identifying the particular relay that functioned. To provide this information quickly, a visible annunciator was designed, for mounting right in the pump room, in an explosion-proof housing, adjoining the station pressure gages and the push buttons which control the three pump units.

With these protective devices, the station can operate at a wide range of pressure conditions within the limits for which the devices are set, and yet have the benefit of protective shutdown when some abnormal condition results in pressures exceeding the prescribed limits.

These vital protective functions are made possible in simple reliable form through the medium of electrical control. Thus, electricity provides not merely the sinews that make Big Inch a moving thing, but also the nerves that direct it and protect it in the performance of its mighty task.

CONTROL FEATURES ON 20″ LINE

NOW let's take a closer look at Big Inch's rival, the 20″ refined-products line. Called "Little Big Inch" because it's a trifle smaller in the waist, it is 200 miles longer, and it really packs a bigger wallop than Big Inch, for its 225,000 barrels per day of refined products represent the equivalent of some 375,000 barrels of crude oil.

Drawing products from eleven refineries in the Gulf Coast area, it runs 350 miles from Beaumont, Texas to Little Rock, Ark., where it joins the right of way of the 24″ line and follows it from there on to the East. Beginning at Little Rock the 20″-line stations are at the same sites as the stations on the 24″ line. Thus substantial savings are effected in costs of right-of-way, station sites, power procurement, energy, operating labor, and maintenance.

Station layout on the 20″ line is quite similar to that of the 24″ line. However, the handling of refined products entails the addition of filter units. The principal differences in the 24″ and 20″ station designs lie in the system of station control, occasioned largely by the greater precision justified in products line operation to minimize contamination between products.

Power-service facilities are entirely similar to those of the 24″ line. The transformers for the two stations at each site operate from a common primary feeder with independent secondary circuits to the respective pump houses.

Consideration has been given to the possibility of installing a 2,300-volt bus tie with a normally open switch. With this arrangement, upon failure of either of the transformers, closure of the tie would permit both stations to be loaded from one transformer which, cooled by motor driven air blast fans, would handle about 5000 kva, permitting operation of selected units in both stations.

The pumps are driven by 1,250-horsepower motors at 3,575 r.p.m., similar to the 24″ line motors in ventilation arrangement. Like the 24″ line motors, these units are coördinated as to mounting dimensions, so that all main pump motors on the line are mechanically interchangeable, regardless of make.

The pumps are single-stage, 14 to 12, operating three units in series, designed to handle 235,000 barrels per day of gasoline, developing a total pressure for the 3 units of approx. 700 lbs./in.^{2}

In addition to low-station-suction

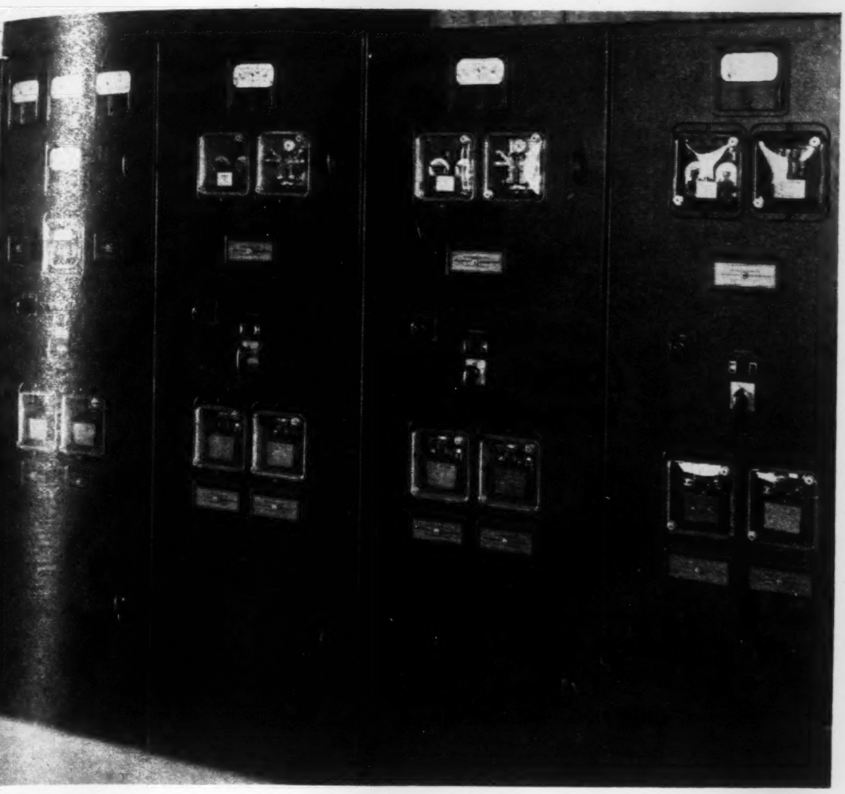

Fig. 3. Typical full-voltage starting switchgear. Left, metering and relaying for the incoming line. Each of the three units at right controls one 1500-hp. motor. Each motor control unit provides time-delay undervoltage protection, instantaneous short-circuit protection and locked-rotor protection, while running-load protection is provided by a thermal relay which follows closely the motor's heating characteristic.

pressure and high-station-discharge-pressure protection, there is a pressure relay connected immediately upstream of the station throttling-control valve. If excessive pressure occurs at any of these points, the relay stops whichever unit is operating as the final unit in the station, and, if pressure conditions are not restored to normal within about five seconds, then it proceeds to stop the next unit in time sequence, and finally, if abnormal pressure still persists, it stops the remaining units.

Temperature-actuated relays are employed in all pump casings, pump bearings, and motor bearings, and on the motor windings.

In general each protective relay actuates circuits to perform three functions: (1) Sound an alarm, (2) Energize an indicating light to identify the protective device that operated, and (3) Stop the unit, or the station.

Air-Operated Automatic Controllers Play an Important Role

A feature in line with recent practice on other products lines is the provision for throttling at the station discharge under automatic control by pneumatic controllers. This control system is designed to throttle the station discharge when necessary to maintain the station suction pressure above a predetermined low limit, say 30 lbs./in.^{2}, or to maintain the line pressure beyond the station discharge below a predetermined pressure, say 700 lbs./in.^{2}.

Nerve-center for all these control operations and protective functions is the station control desk, and the associated sequence-control cabinet. The circuits from the pump and motor rooms, from the lockout push buttons at the pumps, from the motor-operated valves, and from the protective pressure relays and thermal relays, all converge in the station sequence-control cabinet. Here are assembled the necessary electrical devices to translate the incoming impulses into proper action by the switchgear, valves, auxiliary blowers and, when desired, by the station alarm. At the same time the station sequence-control equipment sets up proper circuits to the control desk to keep the operator informed by indicating lights as to the functioning of the various apparatus.

From the control desk all major operations of station control are performed. (See headpiece photo.) Installed in the partition between the control room and the pump room, it is surrounded by a large glassed area permitting view of the pumps and motors. To increase this view, the gage-panel section is designed low, so that the operator can look over the top of the unit.

The gage-panel section consists of a compartment having rear doors opening into the pump room to permit servicing some of the instruments. The front is a panel surface facing the control room, on which instruments are mounted, sealed with gaskets. This gage-panel compartment is gasketed into the partition to prevent seepage of hazardous vapors into the control room, and, as an additional precaution, the control room is kept under a small pressure of clean air drawn from outdoors.

The horizontal surface below and at each end of the gage panel provides writing space and accommodates the station log sheet.

The electrical section of the control desk is really a separate unit isolated from the gage-panel compartment, located entirely within the control room and therefore not exposed to the hazardous atmosphere of the pump room. On this desk are mounted push buttons and indicating lights for the master station control. The desk-top surface is a sheet of transparent plastic, backed with a schematic design of the main piping, and showing the pumps, valves and driving motors.

From a single "start-stop" push button, the operator controls each pump unit, the valve motor control and pump motor control automatically functioning in their proper sequence for starting up and shutting down. Indicating lights in the desktop diagram show the valve positions, and small illuminated arrows show the actual course of the stream through the station piping in accordance with the units operating.

If trouble should develop at any of the protective device locations, a small red indicating lamp appears at the appropriate spot in the station diagram, and the operator is given an audible signal. In general the protective device automatically shuts down the particular unit involved, or the station. In each case the audible signal continues until it is silenced by an alarm cutout button on the desk, and the particular indicating light continues to burn to tell the operator exactly where the trouble is, until it is extinguished by reset of the protective-device, when the trouble is cleared.

This desk and the associated system of control greatly simplify the duties of the station attendant, increase the reliability of station operation, and facilitate location of the trouble spot in case of abnormal shut down. Checking continuously the pulse and the temperature of the station equipment, the desk has been called, rather appropriately, "the pipe line nurse."

The building of the world's two largest pipe lines in less than two years was a tremendous task. It was tremendous in tonnage of materials, in distances and terrain, and in the coördination of work and supplies. To have accomplished these things in the time involved is indeed a tribute to the oil industry, its engineers, and all associates. The electrical industry is proud that within the time prescribed it could coöperate, and coördinate its activity with the broad requirement of the oil industry, not only to supply the prime power, but also to assist in the perfection of control, which contributes so greatly to the performance of the job.

ELECTRIC GAGING METHODS
For Strain, Movement, Pressure and Vibration

By HOWARD C. ROBERTS, Research Staff, Association of American Railroads, Chicago, Ill.

XIII. CALIBRATING DEVICES.

§1. General.

Second only in importance to the measuring system itself, and quite necessary to any actual use of such a system, is the calibrating device. Its function is to provide a physical magnitude of known (and preferably variable at will) value.

Another device or accessory of great practical value and convenience is the calibration-check circuit. This is an adjunct to the system in use; its function is to make available at any time an electrical phenomenon (either a definite change in an operating parameter, or a known potential) which affords an electrical indication simulating that produced by a known physical magnitude. The calibration-check circuit is not a means of calibrating the measuring system, but it does provide a convenient and reliable means of checking the electrical response of the system.

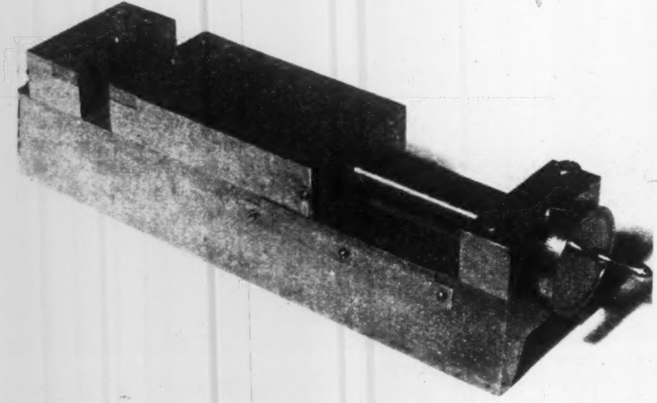

Fig. 1. Calibrating Stand for Movement Gages.

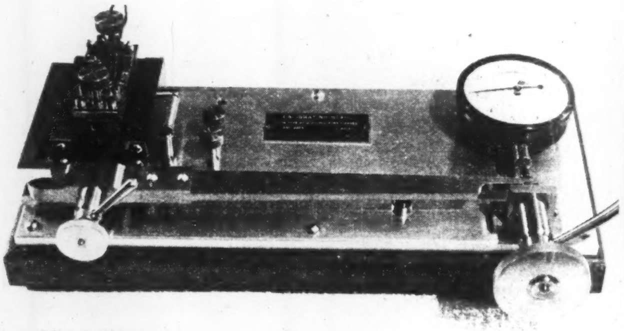

Fig. 2. Strain Gage Calibrator. (*Courtesy Hathaway Instrument Co.*)

Occasionally it is possible to provide a combination of calibrating and checking devices; one such is employed in the balanced-diaphragm indicator. This instrument produces an electrical impulse at the time the unknown pressure becomes equal to a known pressure; in that manner the instrument may be said to need no calibration of its own, or to be self-calibrating. It is extremely useful in calibrating other forms of electrical recording pressure gages, and can also be conveniently employed as a checking device during their operation. Operated within its limitations, the balanced-diaphragm indicator is capable of making extremely accurate comparisons of an unknown to a known pressure; but it is subject to error unless carefully used.

Another method, sometimes used as a means of indirect calibration but more useful as a checking device, involves simulated increments of the electrical parameter employed as an operating principle in a directly-calibrated system. For example, in a resistance-type system employing a slide-wire element, it is convenient to install a second movable contact with a travel limited to one unit of slide-wire length—or, more conveniently, a two-point switch which transfers the contact from one location to another. Or, if a strain-sensitive primary element is used, its effective resistance may be changed at will by shunting it with a resistance whose value may be computed from the known characteristics of the resistance element.

These later methods are best used as checking devices, or perhaps as secondary calibrating devices.

Calibrating devices are available for all of the mechanical magnitudes we measure: movement, pressure, strain, acceleration, velocity, etc. Some are empirical and some based solely on standard definitions, but for each measurable magnitude a device is available for calibration to engineering accuracy. The more common of these devices will be illustrated.

§2. Movement or Displacement: Calibrating Methods

Devices for measuring movement are often grouped in terms of the extent of the movement which can be measured: from "small" to "large." This is also a convenient grouping for the devices used for calibrating them. In measuring strain, for example, the increments employed are of the order of 0.00001″ while a device for indicating water level in a channel or tank may indicate only to the nearest full inch—sometimes only to the nearest foot.

Calibration of a movement gage in large increments, such as inches, presents no special problem. A good quality machinist's scale can be read to 0.01″ or even closer; the only problem is in connection with the installation of the scale, and this is always a matter for the ingenuity of the user.

Strain or movement gages sensitive to a millionth of an inch, and measuring in increments of ten-thousandths or hundred thousandths, require more sensitive and more delicate devices for imparting extremely small but *accurately-known* movements. The micrometer screw is a highly adaptable device for producing and for measuring such movements. The construction and use of the micrometer screw are well known; and in Fig. 1 is shown a calibrating stand containing such a screw. A total movement of four inches is possible, and each division on the graduated dial represents a movement of 0.0002″. Most micrometer screws contain systematic errors, as well as smaller random errors; the one illustrated is not a particularly good one, but its maximum error during its entire excursion is about 0.005″. Within limited ranges of travel the error is only a few ten-thousandths. This calibrating stand can be employed to calibrate movement gages, and strain gages which are attached at their ends only, measuring moderately large values of strain. The parts of the gage are attached to the stand by screws placed in the tapped holes visible in the photograph.

Another useful device for measuring small movements is the indicator dial, or dial indicator. These dials contain a rack-and-pinion or other arrangement so constructed as to magnify the movement of the spindle and indicate this motion on the dial. They are available with sufficient sensitivity to provide an indication of one dial division for each 0.0001″ movement of the spindle. It is usual to provide a micrometer screw or other device to perform the movement, when the dial indicator is made a part of a calibrating stand. The only function served by the dial indicator is to measure this movement.

A calibrating stand designed primarily for use with magnetic strain gages, incorporating a dial indicator operated by a screw through a 10:1 reduction lever, is shown in Fig. 2. Each division on the dial represents 0.00001″ movement at the gage head, and the total movement which can conveniently be accommodated is about 0.030″. The movement is produced by a screw acting at the end of the lever; the dial measures the movement actually occurring at that point. Through the 10:1 lever this movement is transferred, reduced to one-tenth its initial magnitude, to the two blocks carrying the gage parts. These blocks are maintained parallel by a pair of flexure springs, while another screw makes it possible to adjust their relative positions for initial adjustment of the gage setting.

A device of this sort requires careful design and good workmanship to insure that errors remain small; not even the dial indicator itself is free from error—this is easily realized when it is noted that a single tooth on the rack may represent as many as 50 divisions on the dial.

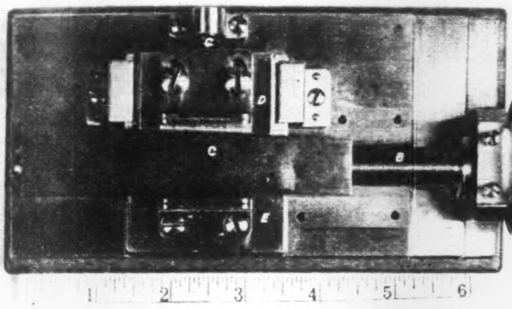

Fig. 3. Wedge-type Calibrator.

Another effective method of coupling the action of a micrometer screw or an indicator dial into a calibrating device is through a sliding wedge. The same mechanical advantage as that afforded by the multiplying lever is available, and in a more compact form. Reduction ratios greater than perhaps 10:1 require cumbersome levers, and consequent danger of lost motion and back-lash; ratios as high as 100:1 are possible with wedges. Such a device is illustrated in Fig. 3.

Among the most precise methods of establishing small increments of motion is the use of gage blocks (Johansson or other). These are carefully finished hardened steel blocks made with the greatest accuracy and in a range of dimensions such that combinations of several blocks can be assembled to provide many fixed reference dimensions. These gage blocks are invaluable for primary standards; with them it is possible to establish dimensions down to approximately a millionth of an inch. For calibration standards they are ideal. It is best to use the gage blocks as standards by which to determine the accuracy of another form of calibrating stand; the gages which are to be used in production then are calibrated on this stand. Gage blocks also may be used to check the accuracy of micrometer screws or dial indicators; especially to locate the ranges over which these secondary devices are capable of their greatest accuracy.

The differential screw has also been applied to the problem of producing small movements of known magnitude; it has not achieved as great popularity as the methods just listed, however, because of the greater difficulty of constructing a stand with little lost motion or back-lash in the differential screw operating it.

§3. STRAIN: CALIBRATING DEVICES.

The most popular strain gages now in use are those which are directly applied; they are attached by adhesives to the specimen and their attachment is continuous along their entire length, not merely at the ends of the gage. For gages of this form, calibrating devices incorporating elastic stressed members are used. Such devices can be used also with other forms of strain gages—with, however, the disadvantage that the application of some forms of gages may cause injury to the elastic member.

Elastic calibrating members may be grouped in two general classes: those experiencing direct or axial strain, and those strained in flexure. (Torsionally-strained members have been used for special purposes.)

In practice, considerable difficulty is encountered in producing a truly axial application of load, either in tension or in compression; even with the most carefully designed loading devices it is necessary to employ a long tension specimen to avoid disturbing end effects; with compression specimens other difficulties appear. The precautions required are far greater than those for the most accurate mechanical testing.

Most of the elastic calibrating members in use are therefore flexural members. Fewer difficulties arise to interfere with the successful supporting of a member in flexure.

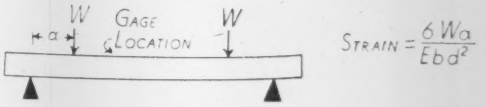

Fig. 4A

A beam of rectangular cross-section, simply supported at both ends, and with equal loads applied at two points properly spaced along the beam, provides a simple means of obtaining known and uniform strain along a considerable length of specimen. With this method of loading, the bending moment—and therefore the strain—along the beam is constant between the two load-points; the dimensions may be made great enough to allow room for the installation of several gages at once. It is necessary that the dimensions of the beam, the spacing of its supports, the modulus of elasticity of its material, and the loads applied, all be known. If all these magnitudes are known, the strain produced by a given load is easily computed. The relation describing this load-strain condition is given in Fig. 4A, with a sketch indicating the manner of application of the load. In this relation, E represents the modulus of elasticity of the material, d the height of the beam, b its width, and a the distance from either loading point to the nearest point of support. Each of the two equal loads is indicated by W.

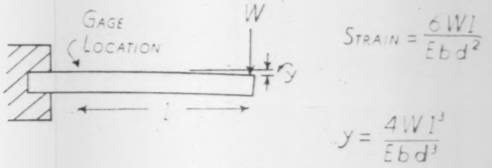
GAGE LOCATION
W
y
l
$\text{STRAIN} = \dfrac{6Wl}{Ebd^2}$
$y = \dfrac{4Wl^3}{Ebd^3}$

Fig. 4B

A cantilever beam is often used as a calibrating member, especially when a dynamic calibration is desired. A somewhat simpler mechanical arrangement is then possible. The general manner of assembly is indicated in Fig. 4B. Here, b represents the width of the beam and d its height; the modulus of elasticity is E and the distance from the point of application of the load to the point of measurement of strain is indicated by l. It may be desired to compute strain in terms of applied load, W, by means of the first relation given; or if it is more convenient to compute in terms of deflection of the beam, y, the second relation may be used.

When a dynamic calibration is desired (as, for example, to calibrate an amplifier sensitive only to rapidly-varying magnitudes) it is almost always more convenient to compute the strain in terms of deflection. A convenient mechanical

Continued on page 624

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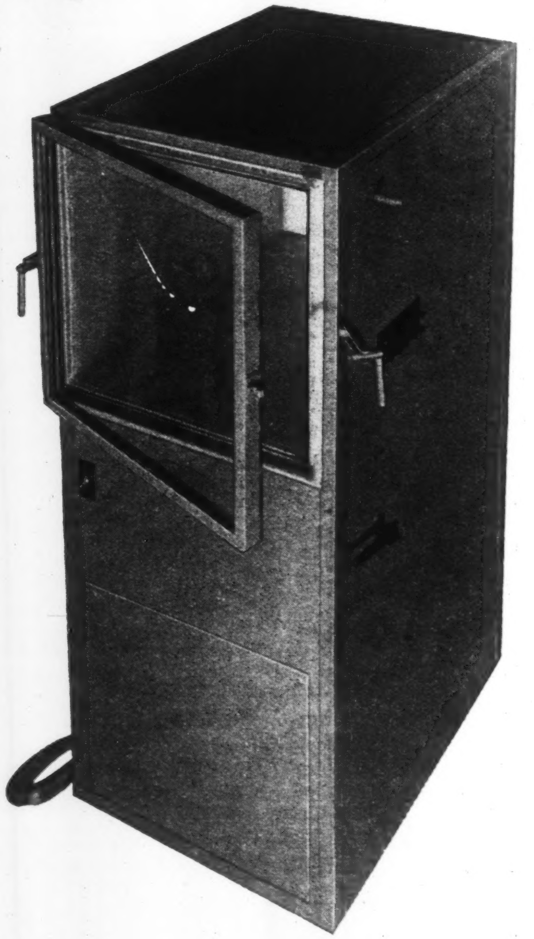

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Vol. IV. No. 9 M. F. Béhar, Editor September 1945

Instrument Landing on Three-minute Schedule Demonstrated by CAA

WASHINGTON, D. C. — New techniques, coupled with very-high-frequency radio equipment developed by the Civil Aeronautics Administration which makes possible landing of twenty planes an hour in bad weather instead of the present maximum of twelve, are now under study by airline technicians.

First demonstration of the new methods was given pilots and officials of the airlines and service air force representatives at Indianapolis by the CAA Technical Development and Air Traffic Control Divisions under simulated instrument landing conditions.

The demonstration pilots made 23 landings and averaged three minutes from the time they left their position at the bottom of the "stacked-up" planes to the time their wheels touched the runway at Indianapolis municipal airport, site of the CAA's Experimental Station.

Planes participating in the demonstration were of two types now used in airline service, and flown by qualified instrument pilots. Windshields of the planes were blanked out and pilots flew through each demonstration on instruments. Six planes were used and the problem they presented to the traffic controller in the tower is typical of conditions that frequently occur at large airports today. All six "arrived" at Indianapolis and wanted to land as quickly as possible.

The best previous time for such instrument landings was four minutes, as demonstrated at Washington in June, where the existing low-frequency range was used along with existing low-frequency communications equipment. With this system, the aircraft are brought down to 400 to 500 feet from the ground, coming in on the range leg.

At the Indianapolis demonstration, VHF static-free two-way communications equipment was used, plus the CAA-developed instrument landing system installed there. Planes were brought all the way down to the runway on the glide path of the instrument landing system, after coming in on the localizer and the marker beacons. In both demonstrations, planes were "stacked" over a holding marker, giving the pilot a ten-mile course on which to line up his approach to the runway.

By the time all airline planes are equipped with VHF receivers, this improvement in bad weather landings will be possible at some 51 airports where the CAA is installing localizers. Ultimately 125 airports will be so equipped, according to present plans.

In the Indianapolis demonstration, the traffic controller "stacked" the planes over a marker beacon at Mooresville, Indiana, about 10 miles from the airport, at 1,000-foot levels, beginning at 2,500 feet. As the planes circled, they heard instructions from the tower to each man as he reached the bottom of the stack, to leave his "fix" and approach for his landing. Then each of the others was instructed to leave his altitude and descend to the next, 1,000 feet lower. Observers on the roof of the administration building heard all conversations over loud speakers, and watched each plane as it approached for a landing.

By "stacking" the planes at this distance from the airport, the pilots were able to line up on the airport localizer beam for a distance of 10 miles, a procedure considered essential to safe practice by CAA officials. No additional equipment on the ground is required, the localizer beam and the marker beacons of the existing VHF instrument landing systems being adequate.

The longest interval between leaving the "fix" and reaching the runway was five minutes, and the shortest two minutes and 20 seconds, the average of 23 landings being exactly three minutes.

Some of the planes were not equipped with VHF receivers, and the tower man instructed them through today's low-frequency transmitters. This illustrated, according to CAA officials, the manner in which traffic will be handled during the transition period while VHF plane equipment is being installed.

"This is stage two in the evolution of Air Traffic Control," officials of the CAA explained to observers. "At a demonstration in Washington two months ago, using today's equipment, we brought five airplanes in within 21 minutes.* That means at most 12 planes an hour under instrument conditions, and today's record shows a possibility of 20 planes an hour. Stage three will come when we can apply the advantages of radar,** heretofore solely a military implement, to civilian and commercial air traffic control."

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*See article, "New Approach System Demonstrated by CAA," *Instruments*, July 1945, pages 472, 474.

**See illustrated article "Future Developments in Instrumentation for All-weather Air-traffic Control," by Glen A. Gilbert of the CAA, *Instruments*, April 1945, pages 237-238, 240. Illustrations show radar screens for collision-warning device and for traffic-control instructions.

Electric Synchronizer for Airborne Guns

NEW YORK CITY.—Gunfire through airplane propellers is now being timed through use of an electric gun synchronizer designed and manufactured by Fairchild Camera & Instrument Corporation. The Fairchild synchronizer system, designated by the Navy as the Mark 3, times the firing of three M-2 .50-caliber aircraft machine guns and provides passage for their bullets through a three-bladed propeller rotating at speeds of from 800 to 1,500 r.p.m.

The electric application for a machine gun synchronizer

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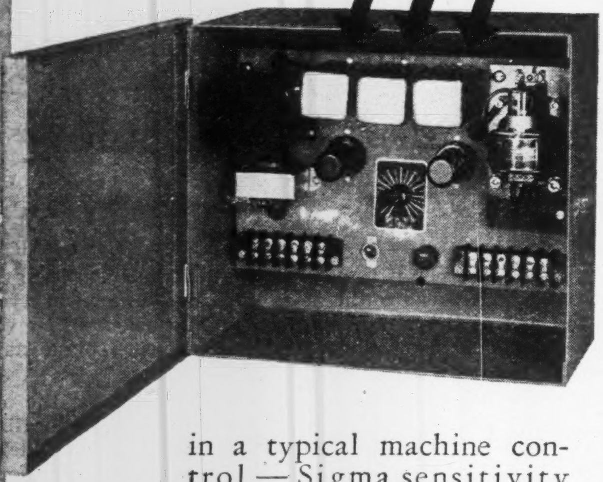

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was originally fostered by the U. S. Army Air Force, and the initial designing was by Jack Gaty, a Fairchild engineer who is now general manager of Beech Aircraft Company. After Fairchild developed the device, however, it was the Navy, not the Army, that put it to use.

The original design of the mechanical synchronizer, which the electrical system supplants, is credited to Anthony Fokker, the Dutchman, working for the Germans in World War I. The electrical application is a definite advance for several reasons: The mechanical system is limited as to how far away the guns can be from the impulse timer unit; for instance, as soon as the mechanical system is three or four feet away from the timer unit, trouble begins, because of complicated cable arrangements, temperature change causing contraction of metals in the cable, etc. But unlike the usual mechanical device, the Fairchild-Mark 3 unit permits guns to be mounted in positions more remote from the motor, firing anywhere within the arc of the propeller. In the Fairchild instrument there are electric leads that go up to and beyond 18 feet, which was, of course, out of reach of the mechanical devices.

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on instrument testing, repair, installing, etc.

This is to remind our readers that *Instruments* pays $5 (or more*) for each shop kink or other time-saving and accuracy-promoting idea accepted for publication.

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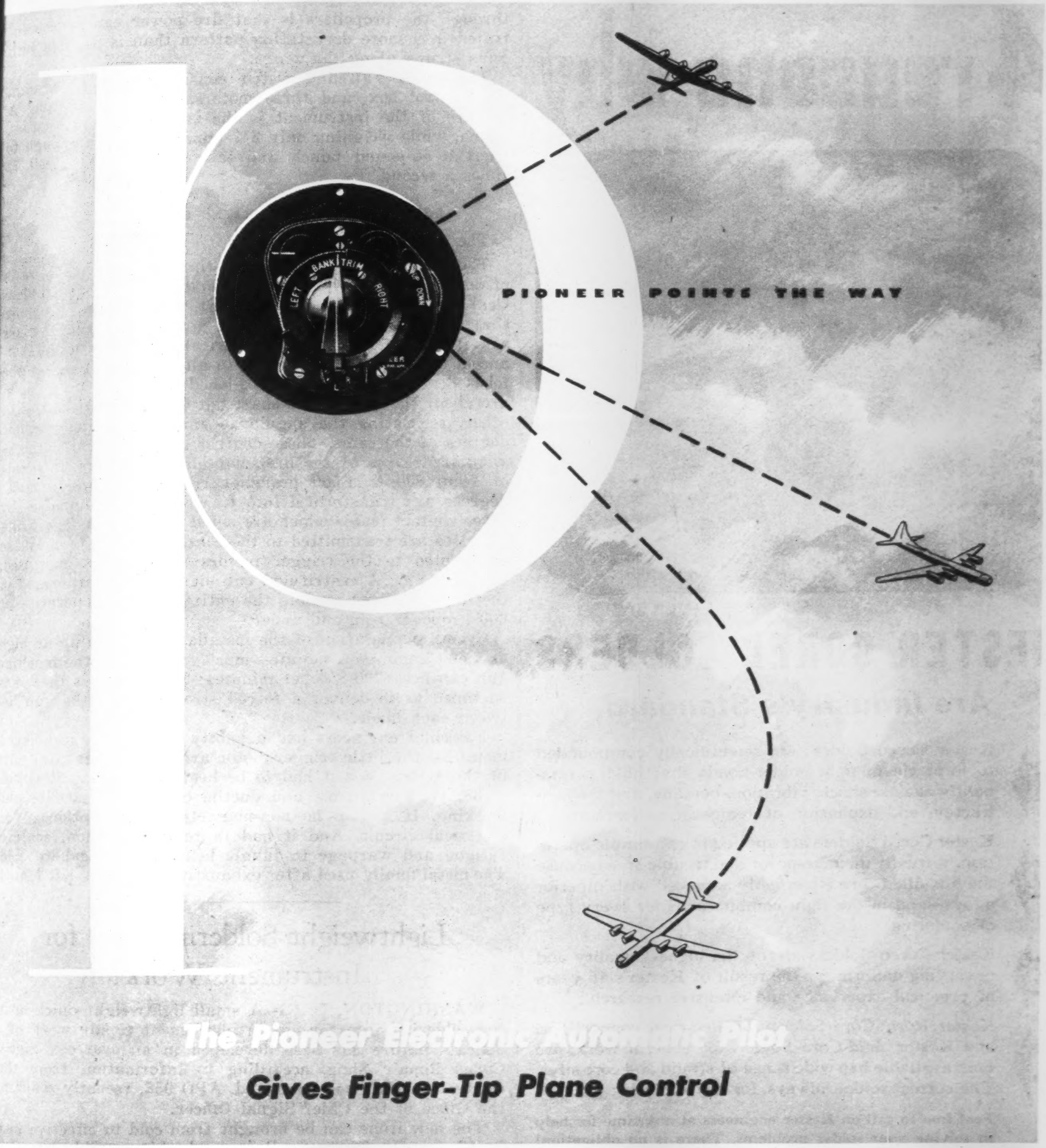
3. **Only professional-grade photos will be accepted (preferably 5 x 7 or 8 x 10 glossies).**
4. **Each contribution to describe ONE method or device. An author may send as many as he likes.**
5. **Mail all entries to Shop Kinks Dep't of *Instruments,* 1121 Wolfendale St., Pittsburgh 12, Pa.**

*Five dollars is for textual entry accepted: a greater minimum is paid for accepted entries including drawings and photographs.

Share Your "Know-how"

Further, in the mechanical system, there is a mechanical takeoff needed on the engine for every gun, and it is not practical to put more than two takeoffs on an engine; on the electrical system, however, there is no limit to the number of takeoffs, although there is a limit to the number of guns which can be fired successfully through the blades of a propeller, and the Fairchild system to date has been used with a maximum of four guns and one cannon firing through one propeller. In addition, it is extremely difficult, if not impossible, to synchronize mechanically with any propeller of more than two blades; electrically, it can be done with three or four blades. Weight and bulk are cut to a minimum with the electric system, and another great step forward is that adjusting the synchronizer for operation is reduced from hours to minutes.

The advantages of all systems for firing aircraft guns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through the propellers is that fire power can be concentrated in a more devastating pattern than is possible with guns strung along the wings.

The entire Fairchild system consists of one timer unit, one control box, and three motors, one for each gun. A feature of the instrument is the trigger-motor armature, which, while weighing only 2¼ ounces, is tough enough to exert a 55-pound punch and take a 110-pound recoil 72 times a second.

ENGINEERING AND OPERATIONAL INFORMATION

The system operates this way:

The main shaft of the impulse timer, geared at the ratio of one to one with the propeller shaft, revolves at an identical rpm with the propeller shaft. Mounted on the timer shaft is an automatic centrifugal governor. Through gears actuated by flyweights symmetrically and statically balanced, the governor is enabled to alter the positions of the lobes of two concentric, three-lobed cams, not only in an arc about the axis of the shaft but also in relation to each other, regulating the angular openings or firing angular degrees of the cams. These degrees are coincident with the angular degrees of the propeller blade openings at speeds of from 800 to 1,500 propeller rpm. The firing angular degrees are transformed into timed electrical impulses by three contact plates which are acted on by cams. The firing impulses are transmitted to the control box where they are distributed to the trigger motors which, thus energized, fire the guns. A centrifugal cut-out switch incorporated in the impulse timer renders the entire system inoperative at 300 propeller rpm and under.

Cycles of operation of the installation can go up as high as 4,500 impulses a minute—much faster than the machine gun can fire (700-850 per minute). The reason is that it is so timed as to deliver a forced stroke to trip the gun between each blade.

Fairchild engineers had a knotty problem in securing a metal for the little trigger-motor armature, most vital part of the system, for it had to be heat-treatable to Rockwell C 38, yet machinable and ductile enough to permit cold-working. It had to be non-magnetic for operation in an electrical circuit. And it had to resist corrosion, scaling, fatigue and warpage in jungle heat or stratosphere cold. The metal finally used after exhaustive tests was KR Monel.

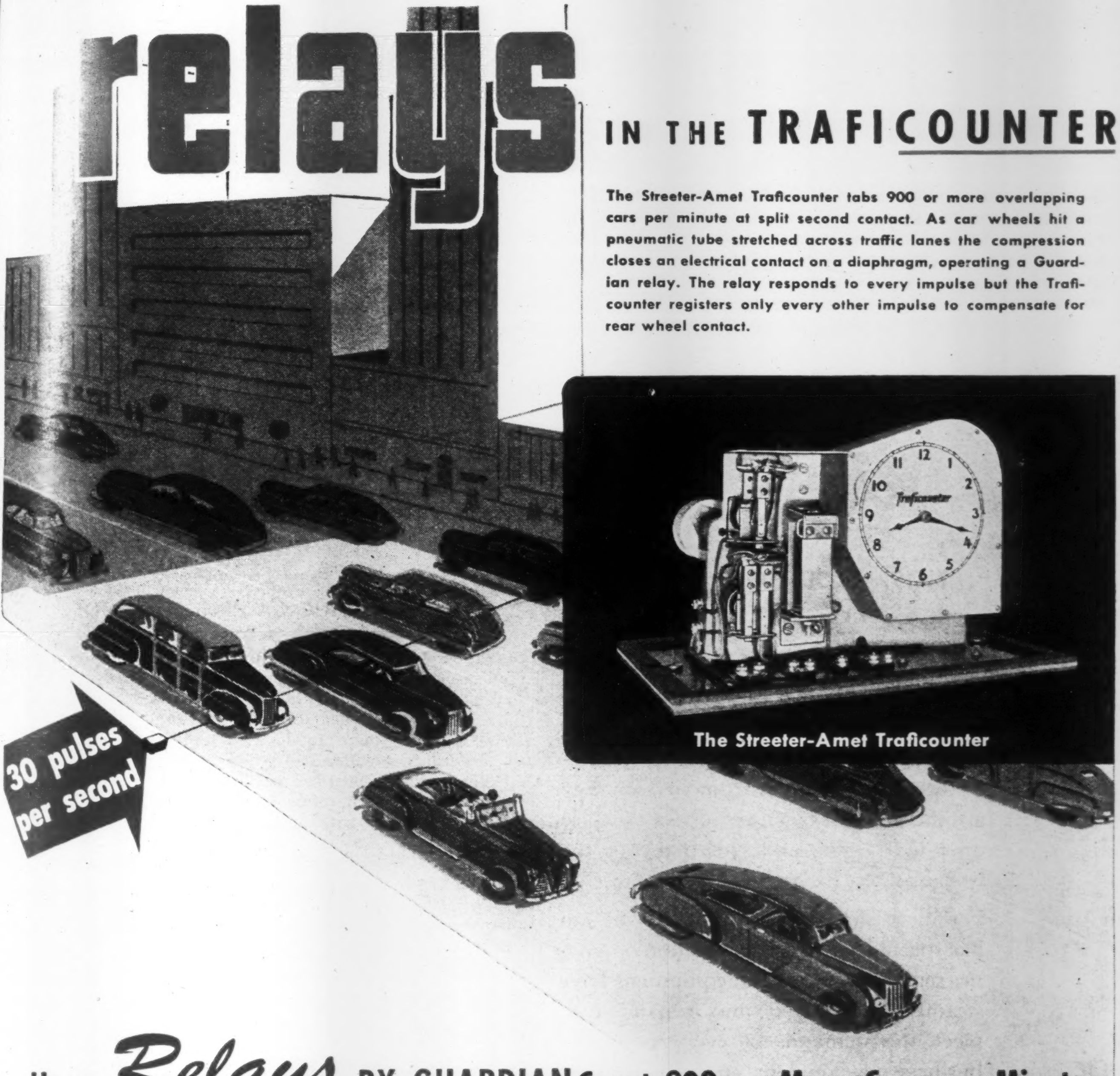
Lightweight Soldering Iron for Instrument Work

WASHINGTON, D. C.—A small lightweight quick-heating soldering iron for use in instrument repair work of a delicate nature has been developed in an overseas Signal Corps Repair Shop, according to information from the Central Pacific Base Command, APO 958, recently reaching the Office of the Chief Signal Officer.

The new irons can be brought from cold to effective heat in 45 seconds. Their smallness makes it possible to reach hard-to-get places, and to perform delicate soldering jobs in instruments. There is enough heat retention to achieve good results.

The heater assembly consists of a transformer having an output of 6 to 12 volts, with a current capacity of 10 to 30 amperes. The power source can be 110 or 220 volts, depending upon the transformer available. Two carbon electrodes are used, and these can be obtained from a standard BA-30 flashlight cell. A suitable fuse is placed in the primary circuit of the transformer for protection against accidental shorting of the secondary.

The basic principles of operation are that with the soldering iron tip inserted between the two carbon rods a current is permitted to flow in the secondary circuit. At the point of contact between the soldering iron tip and the carbon rods a high resistance contact results, forming a small electric arc. The heat developed at these points of contact heats the iron.



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The Streeter-Amet Traficounter

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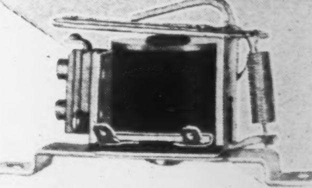

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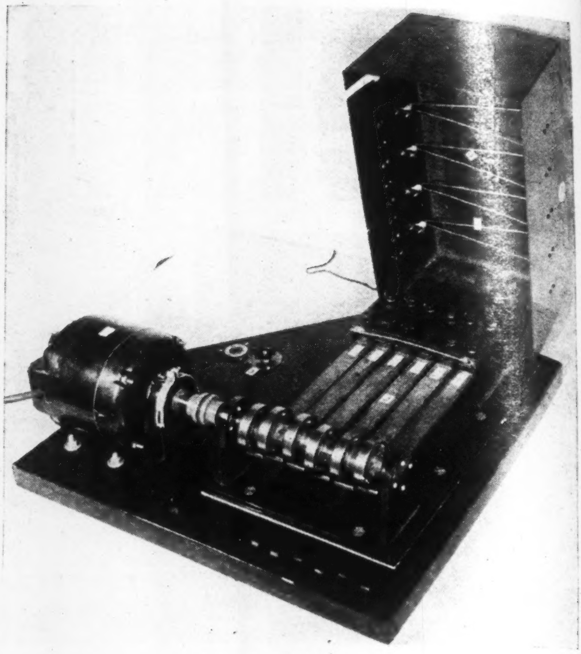

Fig. 5. Dynamic Strain Gage Calibrator.

ELECTRIC GAGING METHODS

Continued from page 617

arrangement is illustrated in Fig. 5. This photograph shows an assembly of six cantilever beams, all deflected cyclically by the electric motor. This particular device is shielded and fitted with heating elements and thermocouples, so that dynamic tests at elevated temperatures can be made. The actuating cams are ball-bearing mounted.

These elastic-member calibrating devices can of course be employed with other types of strain gages than those directly applied with an adhesive cement. Their range is limited by the elastic constants of the material of the beam; therefore they cannot be employed to calibrate any gage over a range of movement corresponding to strains greater than a few tenths of one percent. For greater ranges of movement, one of the calibrating stands shown in Figs. 1, 2, and 3, should be used.

Conversely, the devices illustrated in Figs. 1, 2 and 3 may be used to calibrate strain-sensitive elements of the directly-applied type, in tension only. Difficulty may be encountered in attaching the ends of the strain-sensitive element to the moving jaws of the calibrating stand.

As a rule, the greatest source of error in the use of elastic members as calibrating devices is in the evaluation of the modulus of elasticity of material. All the other quantities occurring in the computation may be ascertained without great difficulty to perhaps 1 part in 1000; the modulus of elasticity may not be known to 1 part in 100. With the high-strength steels ordinarily used for such members, the uncertainty may be even greater.

Another source of error arises in the use of a dynamic calibrator such as that of Fig. 5—the inertia effects of the rapidly-moving members may introduce vibrational strains not taken into account in the computation. These inertia effects increase rapidly with increasing frequency.

In the construction and use of elastic-member calibrators certain precautions should be observed: for example, materials of high elastic limit should be used, and if the modulus of elasticity is low, the range of calibration possible will thereby be increased. The modulus of elasticity should be determined as accurately as possible. Any heat-treating required should be performed with great care.[*]

In the application and adjustment of the supporting fulcra

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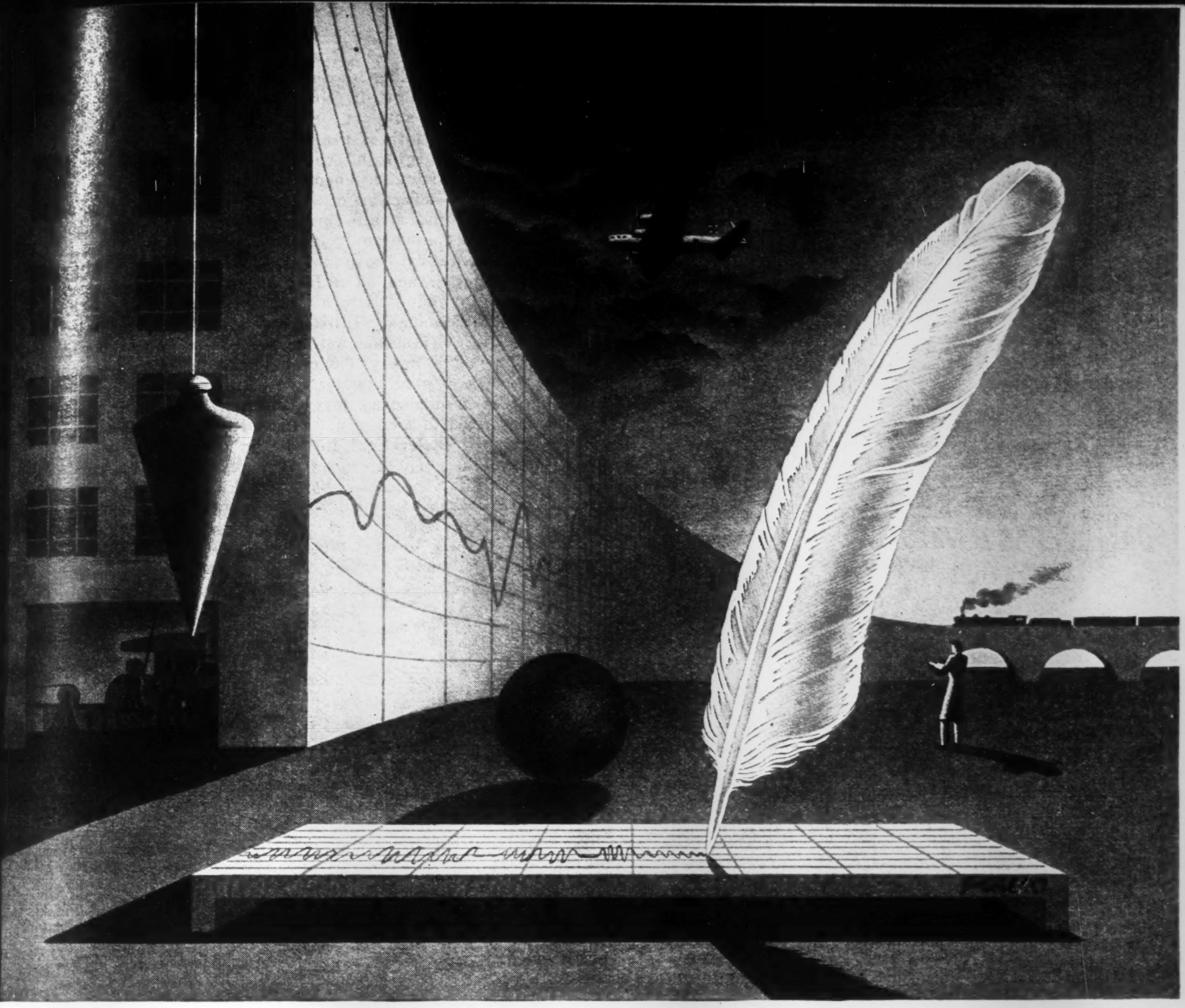
[*] Most observers feel that the most stable and satisfactory material for elastic calibrating members—dynamometer rings, for example—is annealed low-carbon steel. In this application, its limitations, due to its low elastic limit, are obvious.



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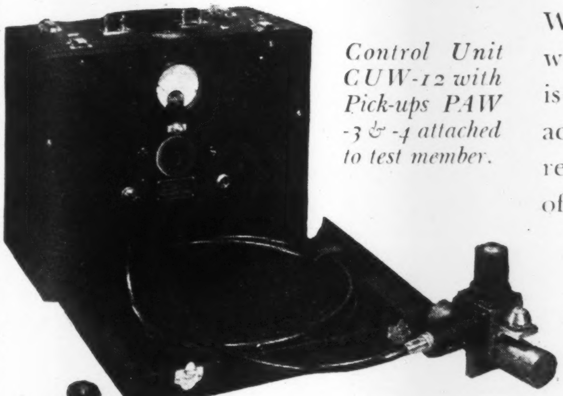

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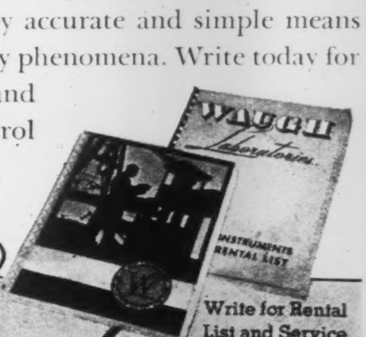

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and the loading devices, ordinary good testing practice should be followed. No gage should be applied too close to a point of support or load—not closer than about four times the width of the member. The elastic member should not be too thin and wide: it will buckle. A good ratio of height to width is about 7:10.

If the deflection of the elastic beam is taken as a measure of the strain, any deformation of the support will introduce an error. It often is desirable to make an experimental calibration of the device with a sensitive mechanical gage, such as a Huggenberger extensometer. (Directions for using these instruments cannot be listed here.)

Elastic-member calibrating devices receive their greatest use in conjunction with other equipment. They are often used as primary devices for establishing the sensitivity factors of strain-sensitive resistance type gages. They are often used also as devices by which a known strain can be imparted to a gage whose sensitivity is already known: the resulting electrical impulse is then used to calibrate an amplifier. In this usage, the device might better be called a calibration-check instrument.

Still another special application of the elastic member is in the production of a variable resistance element for use in resistance bridge circuits. Two resistance type gages mounted one on either side of a small flexural member, provide a pair of resistance elements adjustable within narrow limits around unity ratio, and (since they are in intimate contact with the metallic member) not subject to change in ratio with change in temperature.

§4. PRESSURE: CALIBRATING DEVICES.

The most useful and most accurate of the available devices for calibrating pressure-measuring instruments is the dead-weight tester. This device consists essentially of a piston having a known area (usually 0.1 in.^{2}) upon which known weights can be placed in order to produce an exactly-known fluid pressure. The effects of friction on the piston may be reduced to a negligible value by rotating the piston during the test. The construction of the dead-weight calibrator is indicated in the drawing, Fig. 6A, and one form of the instrument is shown in the photograph, Fig. 6B. Other and more refined forms are also available.

The dead-weight tester may be considered a primary

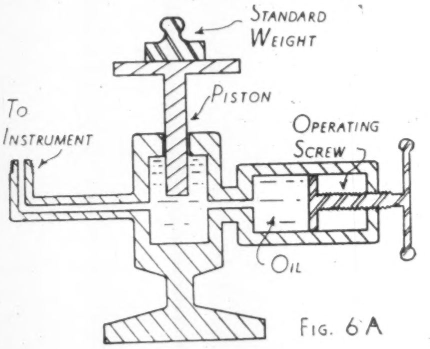

FIG. 6A

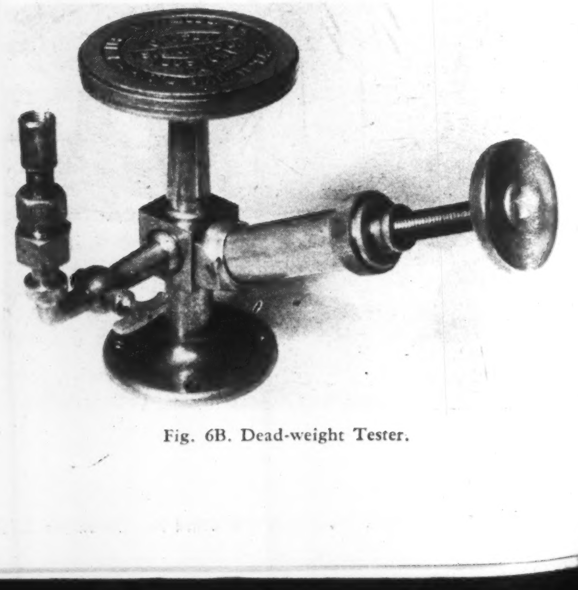

Fig. 6B. Dead-weight Tester.

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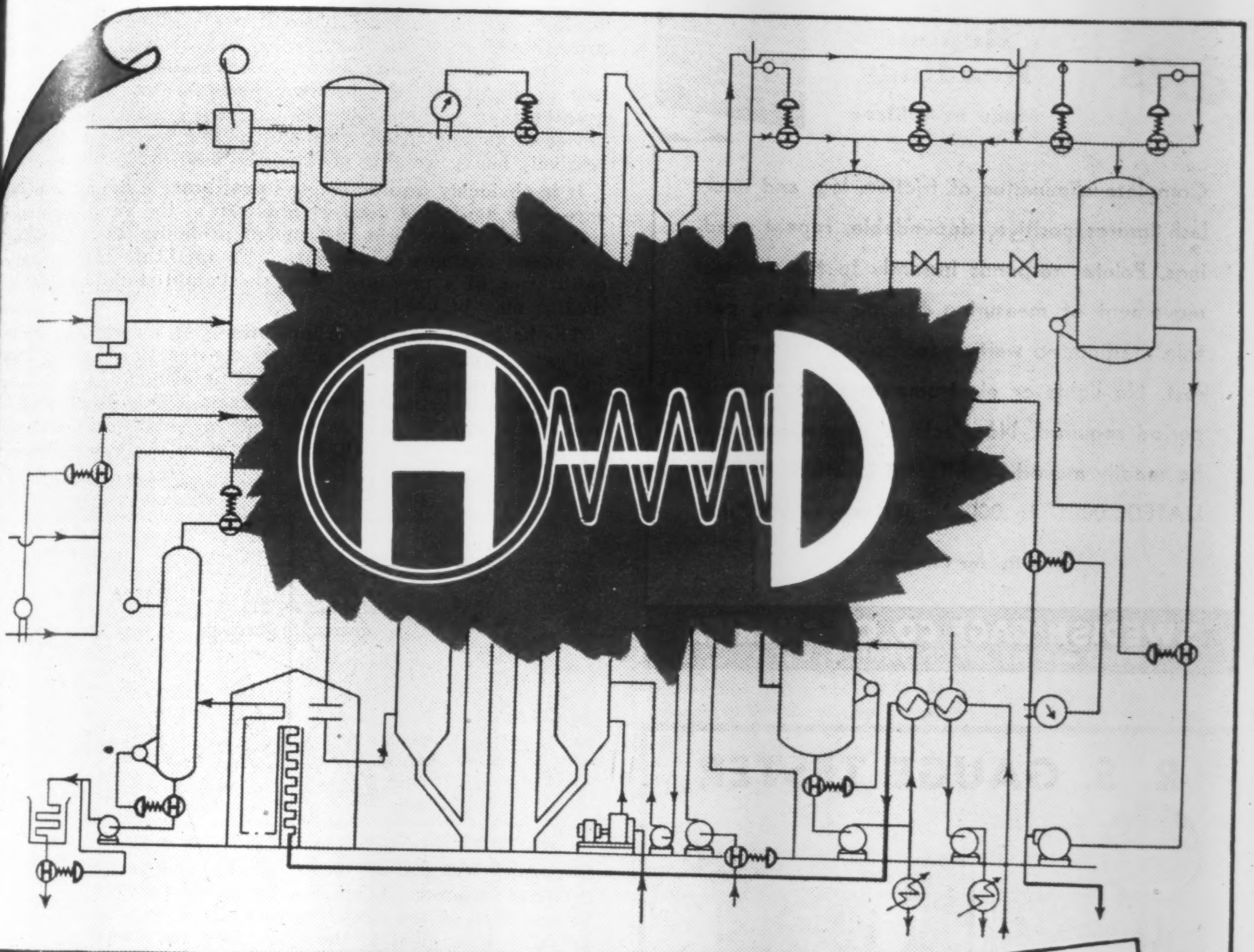

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standard for calibrating pressure-measuring instruments; its operating principle itself represents the definition of pressure—force per unit area. The pressure needed to lift the weighted piston necessarily is equal to the force applied by the weights divided by the area of the piston.

For the production of relatively low pressures for calibrating purposes, the dead-weight tester is less convenient than the U-tube manometer, filled with either water or mercury. Pressures of the order of magnitude of 0.01 lb./in.^{2} may be produced with the water-filled manometer; pressures as great as 15 to 20 lbs./in.^{2} are easily produced with the mercury manometer. Still higher pressures are best produced with the dead-weight calibrator; if pressures greater than perhaps 300 lbs./in.^{2} are needed, the testing device is usually fitted with multiplying levers so that excessively heavy weights need not be used.

It is obviously impracticable to calibrate a dynamic pressure gage against a dead-weight tester; the very construction of the dead-weight instrument prohibits its responding to sudden changes in pressure. To facilitate the dynamic calibration of a pressure gage, the balanced-diaphragm indicator may be used.

The balanced-diaphragm indicator is an instrument which indicates equality of pressure; its construction may be seen in the diagram, Fig. 7. Its actuating element is a flexible diaphragm carrying electrical contacts. This diaphragm is made sufficiently flexible so that a small difference in pressure (perhaps 0.5 lb./in.^{2}) between the two sides will force the electrical contacts together on the side where the pressure is lower. Thus, if a known pressure is maintained on one side of the diaphragm, while a rapidly fluctuating pressure is applied to the other side, an electrical impulse will be produced each time the pressures become equal. Operation is possible if the electrical contact is provided on one side only of the diaphragm, but in order to provide mechanical support for the soft flexible diaphragm the second pair of contacts, on the other side of the diaphragm, should be installed—even though they may not be connected into the electric circuit.

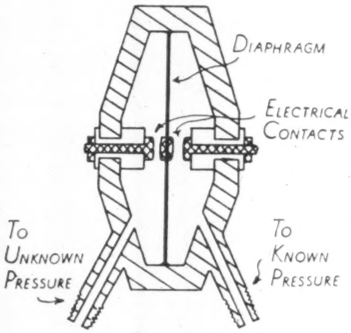
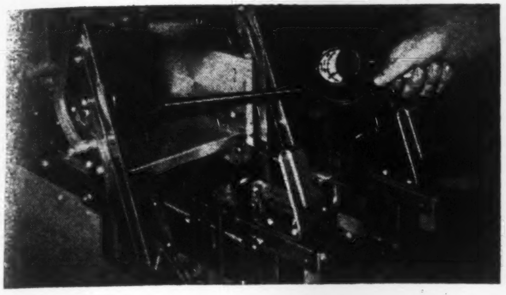


Fig. 7

In use, the balanced-diaphragm indicator may be applied in any of several ways. It may be used as a continuous calibration-check device operated in conjunction with a dynamic recording pressure gage. When so used, a fixed and accurately known reference pressure is applied to one side of the diaphragm, while the unknown pressure is applied to the other side. The impulses from the balanced-diaphragm indicator, recorded simultaneously with the output of the dynamic gage, indicate accurately on the record those times when the unknown is equal to the reference pressure.

Another common use for the device is in the measurement of maximum or peak pressures; this may be done without recording equipment. A pressure known to be higher than the peak pressure to be measured is applied to the reference side of this diaphragm; the contacts will close on the other side. This pressure is then gradually reduced, while its value is read on a suitable gage. When the reference pressure becomes equal to the peak pressure being measured, the contacts open, and an electrical indi-



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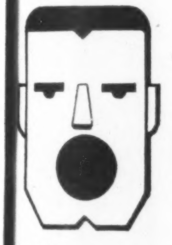

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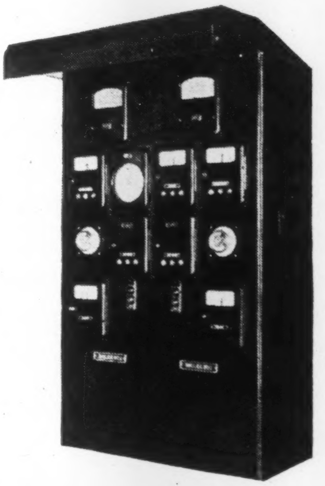

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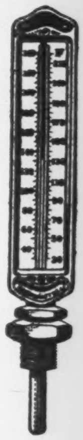

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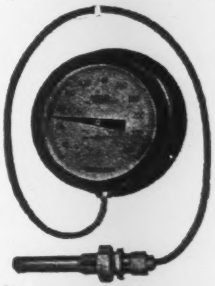

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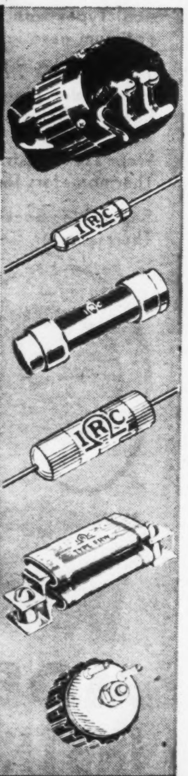

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cation is made. The neon-bulb circuit drawn in Fig. 131 of Part I is well adapted to this application.

Other methods of employing the balanced-diaphragm indicator will suggest themselves to the user.

There are two sources of error peculiar to this instrument. One, occurring in all applications, appears because a slight difference of pressure is required to move the diaphragm from one position to the other, so that the electrical impulse is produced when one pressure exceeds the other by this small amount—not at precise equality. This difference may, however, be made quite small in percentage. The other occurs only in dynamic applications, and is due to inertia effects. The diaphragm, although as soft and flexible as it can be made while still retaining sufficient strength to assure safe operation, has a definite mass and a definite inertia. A pressure pulse of extremely short duration may not cause the diaphragm to move, even though its peak magnitude may be greater than the reference pressure. More important is the effect of inertia and of viscosity upon the gas whose fluctuating pressure is to be measured. If the passages within the gage are too tortuous or too constricted, "wire-drawing" will occur and the pressure within the gage will not always be equal to that in the container where the measurement is desired. It is possible also for resonant vibration to appear in a column of air within a pipe—another source of error.

The three instruments just described are by far the most widely used of all such in calibrating electrical pressure gages; within the last few years improved methods in manufacturing Bourdon type gages have made available gages of this sort which are sufficiently accurate to serve as secondary standards. These gages are especially well suited for use with the balanced-diaphragm indicator. They cannot, of course, follow rapidly-fluctuating pressures.

Although, as indicated above, most dynamic recording pressure gages do not receive a true dynamic calibration (more often they are calibrated statically and several points checked with the balanced-diaphragm indicator) there is available a device by which this can be accomplished. It is an adjunct to the acoustic laboratory—the pistonphone.

For detailed description and for a discussion of its use and its errors, a textbook describing acoustic methods should be consulted. Its use is somewhat difficult, although its construction is simple. It consists merely of a piston and cylinder, of known dimensions, and a motor to move the piston. The variation in pressure within the cylinder may be computed for any piston position, assuming constant temperature. The motion of the piston is not quite true simple harmonic motion; its exact character may easily be computed. The corrections needed for temperature are quite involved; for a discussion of these and other similar factors a textbook of acoustic measurements should be consulted.*

For certain highly specialized applications other instruments might be borrowed from the acoustic laboratory, but the pressures dealt with there are extremely small. Only the pistonphone seems worth transferring to the study of pressures higher than acoustic.

§5. VIBRATION: CALIBRATING DEVICES.

Instruments for measuring the components of vibration require greater care in calibration, and impose greater difficulties in use, than almost any others. Difficulties in operation increase rapidly as the mass of the primary element is increased, since in effect the primary element is made a part of the vibrating system while in use. Difficulties in calibration likewise become greater as the mass of the instrument becomes greater, simply because it is far more difficult to vibrate a heavy object at a known high rate than a light one.

It is convenient to consider vibration as comprising simple harmonic motion, and to describe its components mathematically in that light. Simple harmonic motion is described as a cyclic motion fulfilling this relation:

$$X = a \cos (nt + \epsilon)$$

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*For example, Modern Acoustics, by Davis.

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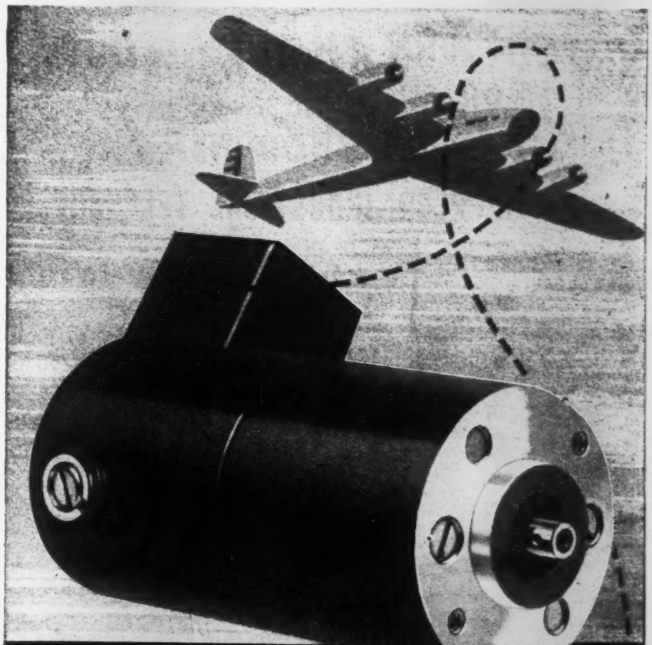

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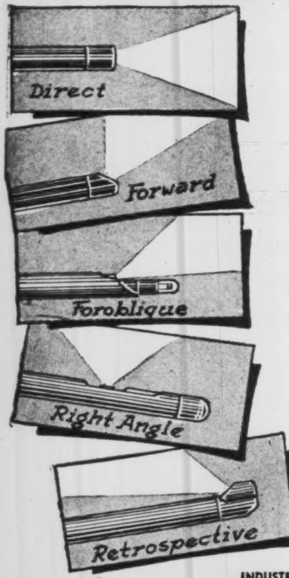

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The displacement at any time is indicated by X, and is equal to the maximum amplitude, a, multiplied by a cosine function. In this function, t represents the time involved, and ϵ the initial phase angle of the system. Each time the quantity nt increases by 2π, a cycle is completed. And each time the cosine function equals 1, the displacement is a maximum. (At this time the velocity is zero and the acceleration is a maximum.) The velocity may be computed by taking the first derivative in terms of time:

$$\frac{\partial x}{\partial t} = -\,an \sin\,(nt + \epsilon)$$

And likewise, the acceleration at any point in the cycle can be computed by taking the second derivative in terms of time:

$$\frac{\partial^2 x}{\partial t^2} = -\,n^2\,x$$

A convenient form of this expression for acceleration may be developed by reducing the known terms; then

$$G = 0.1022\,af^2$$

where G represents the acceleration in "gravities" of 32.2 feet per second per second, and f the frequency in cycles per second.

The validity of this method of description depends upon the fact that any repetitive wave-form, no matter how complicated, can be described by a summation of sinusoidal wave-forms, of proper frequency, phase-angle, and amplitude. Conversely, any irregular repetitive wave-form can be reduced by a Fourier analysis to a group of component sinusoidal wave-forms. It is therefore justifiable to assume that an accelerometer calibrated in terms of simple harmonic motion (sinusoidal wave-form) can be employed to record irregular and non-repetitive wave-forms so long as they do not contain components representing frequencies higher than those for which the instrument is calibrated.

It is customary to employ primary elements sensitive to acceleration for vibration measurements; if velocities are required, an electrical integration is performed, and if displacements are required, two such integrations are performed. This is of course purely a device of convenience. Velocity-sensitive primary elements are sometimes employed, and occasionally elements sensitive to displacement. In calibrating an instrument for the measurement of any of these three magnitudes, a vibrating test stand of some sort is best used. Both the amplitude and the frequency of vibration should be adjustable; in this way a wide range of velocities and accelerations may be accommodated, and the effect of frequency on the instrument likewise determined.

These vibrating test stands are usually operated by mechanical, by piezoelectric or by magnetic driving units.

Mechanically-driven vibrating test tables may operate on either of two principles: they may be the direct-drive type or the reaction type. The direct-drive type employs a cam, an eccentric, or a Scotch yoke to convert the rotary motion of a motor to an approximate simple harmonic motion. The reaction type employs a rotating unbalanced mass running in bearings attached to a spring-suspended table; the unbalance forces produced by this rotating mass cause the entire assembly to vibrate. The frequency of vibration of both types is controlled by the speed of the driving motor. Both types, the direct-drive and the reaction, are diagrammatically illustrated in Fig. 8.

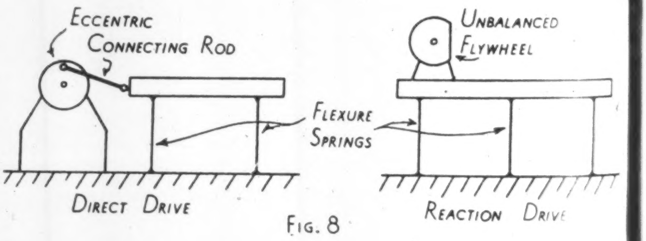

FIG. 8

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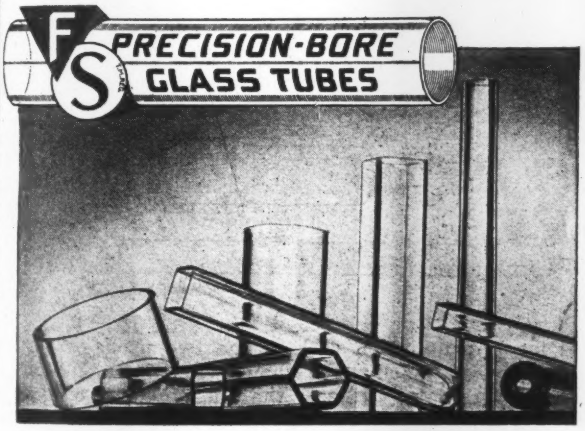

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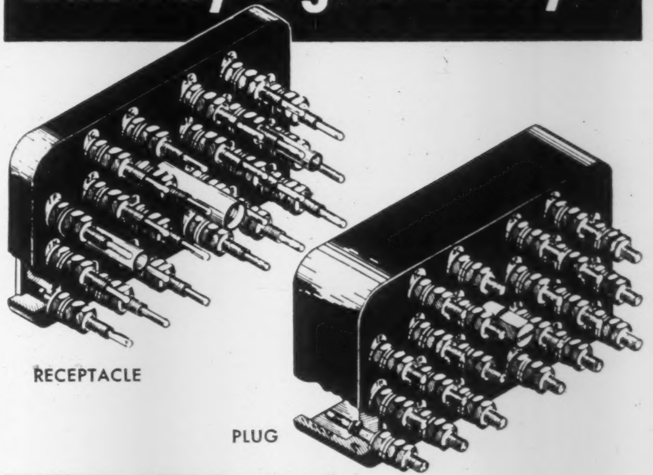

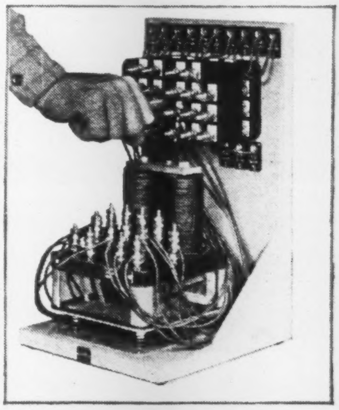

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that the amplitude of vibration is easily and accurately controlled by adjusting the throw of the eccentric; with this and the motor speed accurately known, the accelerations produced may be computed quite accurately. The reaction type, though simpler in construction, is less easy to adjust, and the amplitude is not accurately known unless specifically measured. With the direct-drive construction, it is possible also to produce accurate simple harmonic motion. To do this, it is necessary to employ two eccentrics with connecting rods, with their outputs so connected that the second harmonics of the sinusoidal motions oppose and counteract each other, leaving only a true sinusoidal motion of the table itself. A vibrating table employing this form of construction is illustrated in Fig. 9.

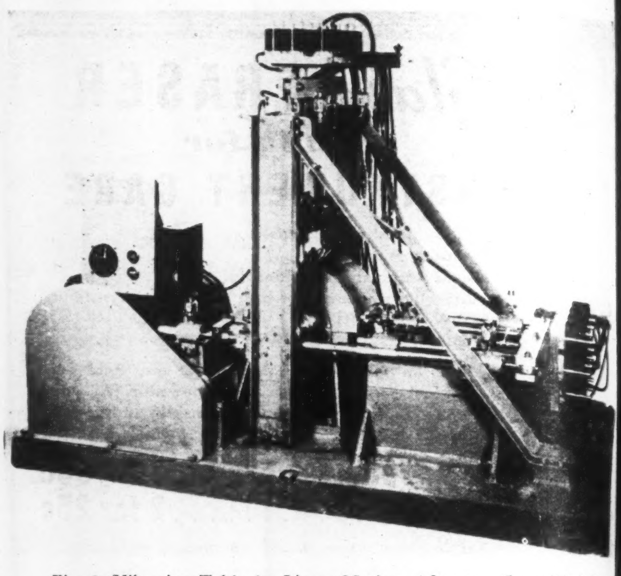

Fig. 9. Vibrating Table for Linear Motion. (*Courtesy Consolidated Engineering Corp.*)

Magnetic-drive vibration test stands usually also employ the principle of mechanical resonance in order to provide greater amplitude. One form, especially applicable to loads of small mass, somewhat resembles a tuning fork, with two equal loads mounted on each of the two prongs. The frequency of vibration may be changed by adding or removing small auxiliary weights; the amplitude by controlling the amount of electrical energy admitted to the exciting coil. See Fig. 10. Higher frequencies, with smaller amplitudes, may be produced by a vibrating system composed of a straight rod carrying the loads at its two ends, and set into longitudinal vibration. This form of construction is diagrammed in Fig. 11. With both modes of construction, the use of the resonant mechanically-balanced system has a considerable advantage over unbalanced systems in that there is little or no vibrational energy transmitted to other objects through the mounting devices.

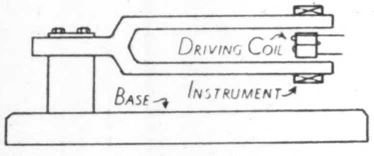

Fig. 10

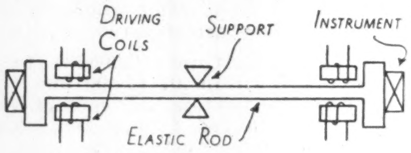

Fig. 11

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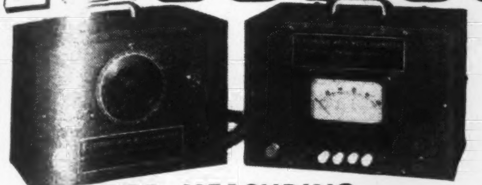

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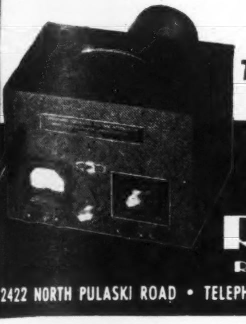

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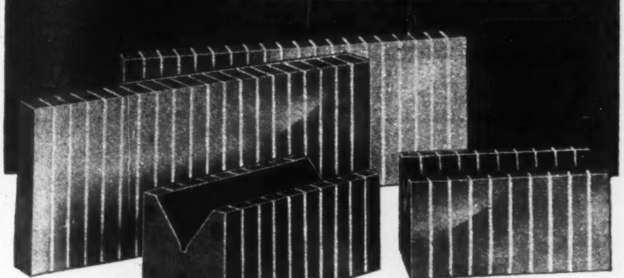

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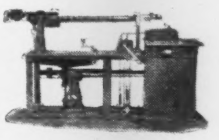

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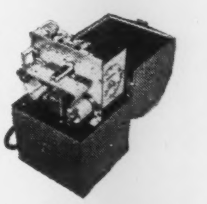

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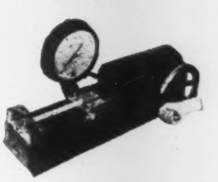

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to the production of small-amplitude vibrations of high frequencies. The crystal element used is that illustrated in Fig. 116, Part I, and called an "expander" element. Ordinarily, a number of similar crystals are placed mechanically in parallel, to provide greater capacity. This form of construction makes possible vibrations at frequencies as high as twenty thousand per second; even higher frequencies may be produced, but mechanical resonances within the crystal mountings often give rise to trouble at the higher frequencies.

Precautions must be taken against resonant vibrations of parts of the calibrating stand, no matter which of the systems described is used; excepting, of course, in the instance of the deliberate use of mechanical resonance of the entire elastic system as a whole. These resonances often appear in eccentric-driven shake tables, in which some portion of the apparatus is set into resonant vibration inadvertently. Such spurious vibrations obviously introduce error. Their elimination ordinarily requires rigid construction, the use of light materials for moving parts, and the installation of mechanical damping if necessary.

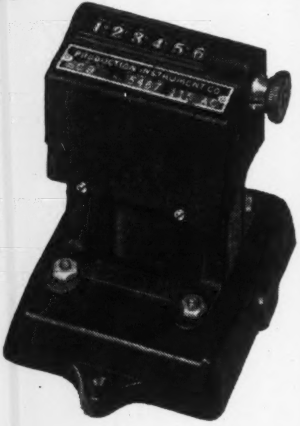
§6. OTHER CALIBRATING DEVICES.

Precision instruments are available for measuring temperature and time, and methods have been standardized for accurate determination of electrical magnitudes. This treatment has been intended to deal with the common engineering magnitudes; those listed above will cover the major part of the engineering needs. Other related magnitudes—flow, volume, specific gravity, and the like—are measured ordinarily by indirect methods. Flow, for example, is often measured with an orifice or a Venturi tube; in this case the problem becomes one of calibrating sensitive pressure-indicating instruments.

Detailed and useful descriptions of these other instruments and methods are available in other works of reference.

To be continued

Wizard Electric Counters



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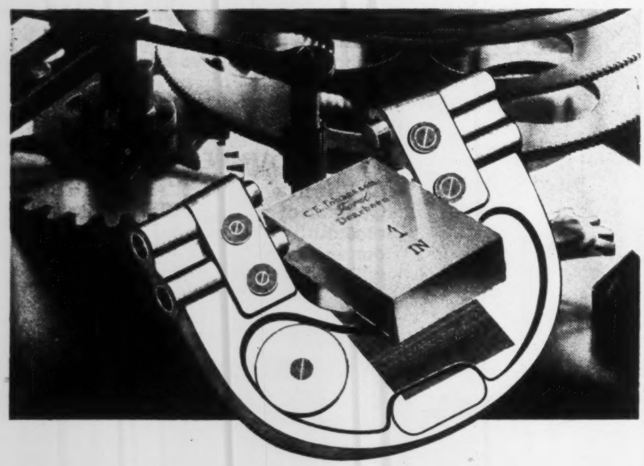

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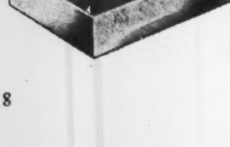

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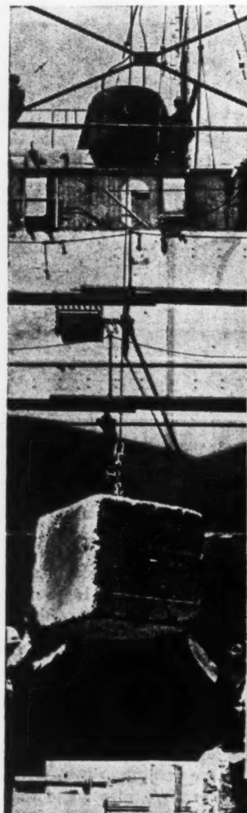

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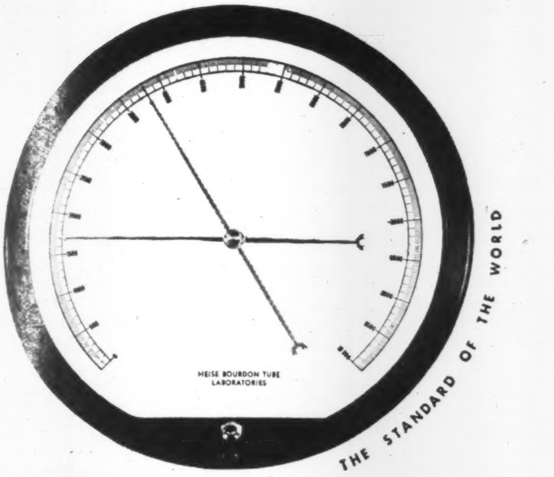
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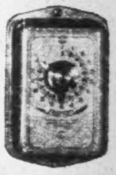

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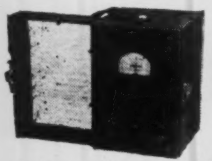

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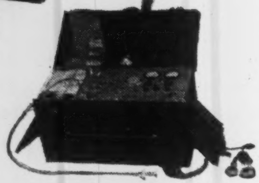

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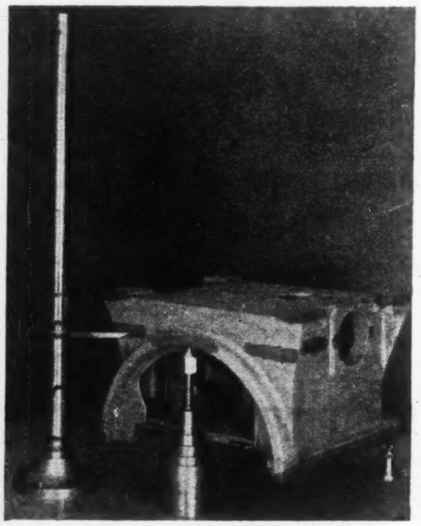
INSTRUMENTS ON THE MARCH

Multiple-height Gage

SCHENECTADY, N. Y.—A multiple height gage, designed by Charles Rohlfs of General Electric's Pittsfield Works inspection department, has simplified scribing of gear housings and their inspection after machining, and considerably reduced layout time. Dial indicators can be clamped to the multiple scribers and set to required dimensions to inspect quantities of identical parts.



Relatively simple to make, the gage consists of a center column-rod threaded into the base and secured by a lock nut. The spacers and scribers, hardened and ground, are drilled to slide-fit the column rod. The spacers are ground to dimensions that will place the scribers correctly for the layout of the required lines for machining. After these are placed on the rod and correctly spaced, the assembly is secured by a cap nut. To compensate for the variations in unmachined castings, the complete assembly of spacers and scribers can be adjusted higher or lower, without disturbing any of the dimensions between the scribers, by loosening the lock nut and screwing the center column rod in or out of the base, as the case may be.

By using a set of spacers for each drawing, the scribers are easily spaced and secured, and any quantity of identical parts can be rapidly laid out. This new gage eliminates the use of the conventional gage, which had to be set for each line and the reading checked before scribing.

Tiny Strain Gages Aid Design of Large Structures

WASHINGTON, D. C.—How military and industrial engineers have been solving ordnance, aviation and machinery problems with a testing gage no larger than a paper clip attracted some of Washington's leading research and testing authorities to a three-day conference. Purpose of the conference was to enable industrial engineers to exchange information on the uses to which the gage has been put in measuring stresses and strains in materials and machinery of all kinds and to apply this knowledge to postwar industrial research.

Sponsor was Baldwin Locomotive Works Southwark Division which makes the gage, known as the "SR-4" Strain Gage. Attending were experts in the fields of aeronautics, railroading, shipbuilding, ordnance, civil engineering and numerous sectors of manufacturing. The scientists heard F. G. Tatnall and C. H. Gibbons, of Baldwin's testing machine department, relate how the gage has provided vital information for improved design of guns, airplanes, ships and other fighting equipment during the war. Actual operation of the gage was demonstrated at the meeting held at the Statler Hotel.

Photographic Computer for Army Signal Corps Motion Picture Camera

NEW YORK—Shown here approximately half size is a photographic computer for motion picture cameras, produced by the Hopp Press, Inc., for the United States Signal Corps Photographic Center, Long Island City. Material used is Vinylite plastic sheeting, a product of the Bakelite Corp. This material is particularly adaptable for a computer of this type. It can be exposed to heat and cold, moisture, grease, etc. It is permanent; will withstand rough handling. The life of the product is almost indefinite.

The computer is laminated with a transparent Vinylite sheet, bonding a protective surface over the reading matter, so that the print is guaranteed against washing off, erasure, etc. The surface is dull or matte finish, permitting pencil or ink notations and calculations to be made in the blank columns provided. This may be erased or washed off without affecting the print. This feature is particularly advantageous, since calculations can be made, notations jotted down, without the use of extra pads or paper. These figures can be arased and the blank lines used over and over again.

In order to reduce the size of the finished computer, additional tables are

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New and improved SOMCO optical methods, new ideas, new products, born of war experience, are now at your disposal.

And, you may be sure that SOMCO peacetime products will embody the same quality, craftsmanship, precision and experience that won for us five Army-Navy citations. This means even finer precision optics than you enjoyed before.

Our engineering and research staffs are ready to serve you now. Write today.

OUR *WARTIME* STANDARD BECOMES OUR *PEACETIME* OBJECTIVE

THE SURRENDER OF JAPAN clears our last barrier! From now on it is full steam ahead to peacetime production—full production.

All of us have a tremendous responsibility in shaping America's future. It is largely up to American industry to work for full production which means full employment, and that spells prosperity.

The war proved that American industry had the capacity, the ingenuity, skill and the will to produce for Victory against time and great obstacles.

If we can successfully produce for War—we can successfully produce for Peace. Let's put forth that very same energy, skill and will to make America a strong, happy and prosperous nation. So . . . Let's GO!

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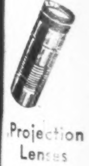
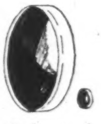
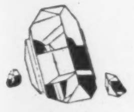
We have facilities for producing low reflection coatings, aluminizing and silvering



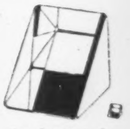
Projection Lenses



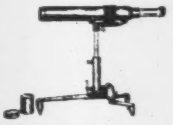
Spherical Lenses



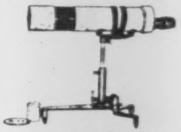
Roof Prisms



Right Angle Prisms



Spotting Scope Draw Tube Type

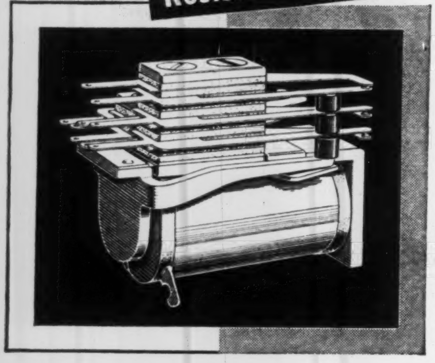


Spotting Scope Prismatic Type

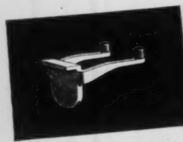
CLARE

...Type "K" Relay

Resists Vibration

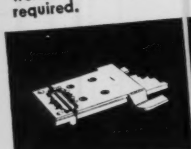


Clare Type "K" Relay, originally designed for aircraft use, has special advantages for applications requiring extremely small size, light weight and unusual resistance to vibration. Armature is held by a special reed type armature bearing made of heat-treated beryllium copper which is practically fatigueless—no anti-vibration springs necessary. Short contact springs are vibration-resistant. Overall dimensions are 1½"x1¼"x1-13/16"; weight, approximately 1⅝ ounces. Like all Clare Relays, Type "K" can be "custom-built" to meet unusual requirements. These five features are good reasons for specifying Clare Type "K" Relays in your instrument applications:

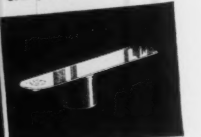


1. Armature assembly, single or double arm; stainless steel shaft; adjustable or welded residual as required.

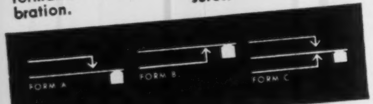
2. Nickel silver springs to which contacts of silver or of palladium are overall welded by a special patented process.



3. Hinge of "fatigueless" beryllium copper insures long life and accurate performance under vibration.



4. Strong, hard, long wearing bakelite bushing insulators resist vibration and heavy contact pressures.

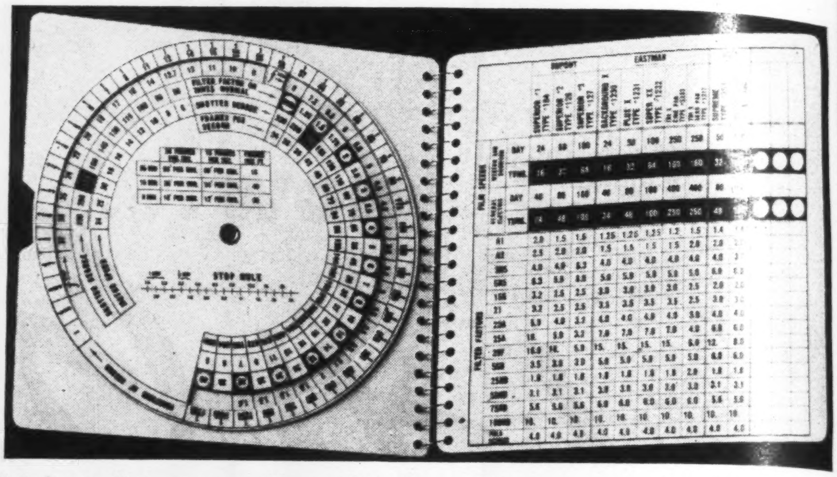


5. Contact springs can be supplied in any of the three forms shown, or any combination of them.

Let Clare engineers "custom-build" a relay to your requirements. Write for catalog and data book. C. P. Clare and Co., 4719 Sunnyside Ave., Chicago 30, Illinois. Sales engineers in all principal cities. Cable address: CLARELAY.

CLARE RELAYS

"Custom-Built" Multiple Contact Relays for Electrical, Electronic and Industrial Use



listed on the reverse side, and both pieces spiral bound in order to afford greater ease in the handling of the instrument. Thumb hole is placed on side, so as to enable user to turn revolving disks easily with the left hand while making necessary notations with the other hand.

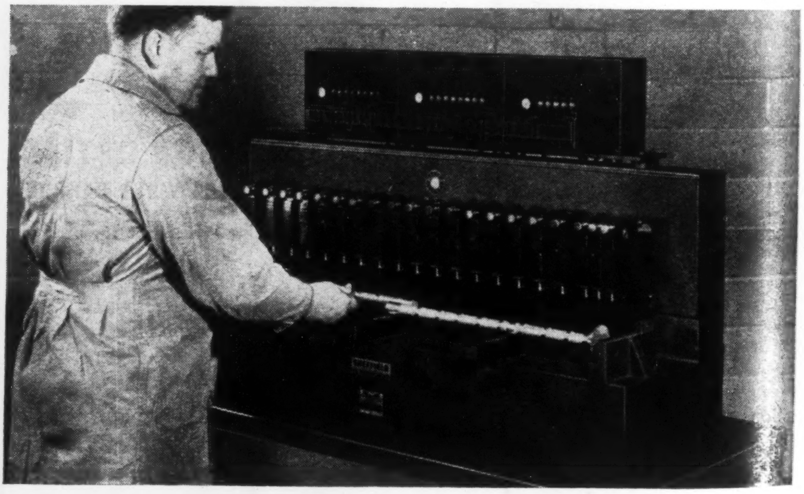
Every operation, from type setting to finished product, was handled in the Hopp plant, entirely from blueprints submitted by the Signal Corps.

Twenty-one Points Checked Simultaneously by Special Camshaft Gage

DAYTON, Ohio—A recently-released photograph shows an interesting example of how a multiple electric precision gaging instrument has been built for accurate and rapid checking of twenty-one outside diameters of a master camshaft. Each of the dimensions is indicated on the diagram panel by means of light signals, and all are checked simultaneously in one quick operation. In this application, thirteen dimensions have tolerances of 0.0005", six have 0.010", and two have 0.001". In the photograph, the operator is shown placing one-half of a master gage in proper position for setting up; the other half may be seen in the right foreground.

Each of the 21 "Electrichek" gage heads actuates a set of two individual signal lamps mounted behind a common port in the light case. Lights remain off when the dimension is within tolerance limits. When a light bulb shows red, it indicates that the dimension is under the minimum tolerance limit, while a green light signifies the dimension is larger than the maximum. The operator needs to watch only one master light which remains off when all the dimensions of the part being checked are within tolerance limits. If any one or more dimensions are either undersize or oversize, the master light comes on, and the operator refers to the diagram panel to see which signal light shows red or green to indicate the error.

"Multichek" instruments, developed by the engineers of The Sheffield Corp., are "tailor-made" to meet individual requirements and are recommended where inspection is required of a large number of pieces. The number of dimensions may vary from two to more than twenty, depending, of course, upon the item to be checked. Once the instrument has been properly set up, the actual work



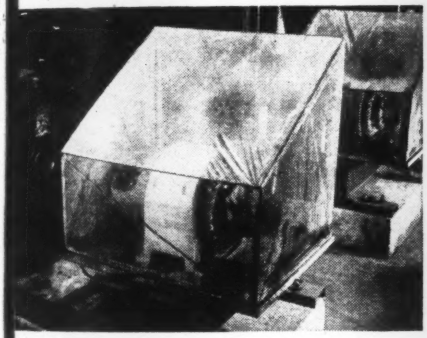
DOW CORNING

SILICONES

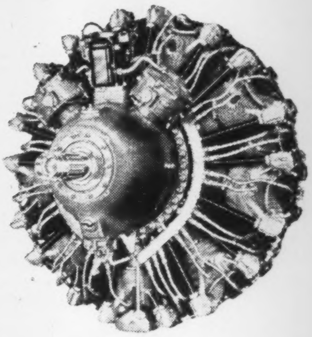
Exclude Water

. . . even after aging at elevated temperatures

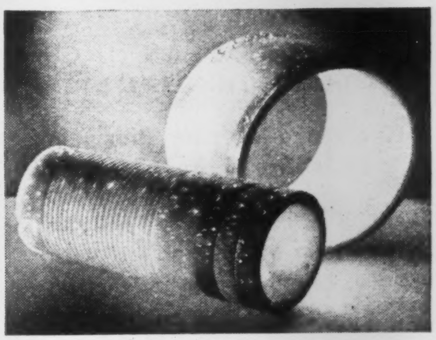
Water repellency is one of the basic properties of Dow Corning Silicone products. Exceptional stability over a wide temperature range is another. These two properties recommend Dow Corning Silicones for the solution of many hitherto insolvable industrial problems involving the exclusion of moisture at elevated temperatures.



DC VARNISHES and RESINS have made possible Silicone Insulation, a new class of electrical insulation which excludes moisture from equipment operating in wet or hot locations despite normal operating temperatures of 175° C.



DC COMPOUNDS are heat stable materials easily applied to form a waterproof dielectric seal for disconnect junctions in ignition systems, radio and radar equipment. Non-melting, low freezing properties keep compound where it belongs.



DC FLUIDS, colorless, odorless, inert liquids, form a durable water repellent film over glass and ceramic surfaces to enable insulator bodies to retain their originally high surface resistivity even after immersion in salt water.

DC Silicone Varnishes, Fluids, Greases, Compounds and Rubber (Silastic*) are in commercial production and in general distribution. Inquiries are invited concerning your particular problems involving moisture exclusion, high temperature insulation and special lubrication.

*TRADE MARK, DOW CORNING CORPORATION

DOW CORNING CORPORATION
MIDLAND, MICHIGAN
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Dow Corning

FIRST IN SILICONES

WIRE SO FINE
IT MUST BE
Magnified
TO BE SEEN

WOLLASTON PROCESS
Wire as small as
1/100,000 OF AN INCH IN DIAMETER

. . . available in Platinum and some other Metals

.00001" is less than 1/30 the diameter of the smallest wire die commercially available. Yet our Wollaston Process wire (drawn in a silver jacket) closely meets your specifications for diameter, resistance and other characteristics.

●

This organization specializes in wire and ribbon of smaller than commercial sizes and closer than commercial tolerances. ***Write for List of Products.***

SIGMUND COHN & CO.
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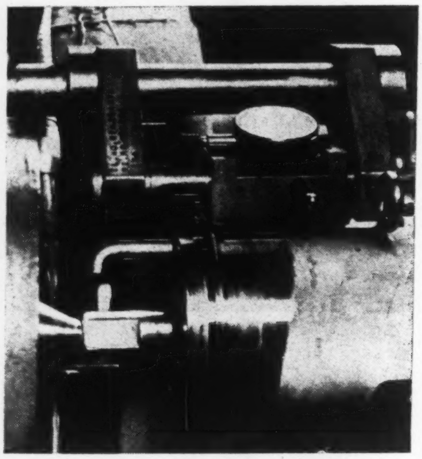
of checking parts may be done rapidly and accurately by an inspector who is merely required to load and unload the parts.

Carbide Fingers Insure Accurate Gaging During Grinding

DETROIT, Mich. — Use of carbide gage fingers has insured accurate gaging during grinding at a large aircraft engine plant here, under conditions which would wear steel fingers away so rapidly that the operator would be forced to continually re-set his gage.

The job where these fingers are used (shown here) consists of grinding the O.D. of aircraft cylinder sleeves to extremely close tolerances. The gage fingers—made of Carboloy cemented carbide where they contact the rotating work—are so set that when the gage reads "0" they automatically shut off the machine feed, thereby saving an appreciable amount of time on long production runs.



Since no lubricant can be used on these gage fingers for obvious reasons, it is impractical to employ steel for this purpose since steel would wear away so rapidly that the operator would be forced to continually re-set his gage to maintain accuracy. The Carboloy fingers, however, stand up under these conditions and are reported to have made this type of gaging fixture practical with a resultant material increase in production.

Instrument Salvage Presents Serious Radium Hazard

TERMINATION of Government contracts for instruments and other war materials containing radium may create a widespread radium hazard, unless proper control measures are taken. With the probability that these materials would be salvaged by individuals who are unaware of the dangers of radium exposure, the War Production Board, U. S. Public Health Service, and Army Service Forces and Air Forces have taken steps to avert this threat.

Dr. Thomas Parran, Surgeon General of the U. S. Public Health Service, in a letter to the War Production Board, recommended that the disposal of salvaged war materials containing radium be prevented until safe methods of handling could be planned and effected. In view of the public health indications if these materials should get onto the open market, the cooperation of the Public Health Service was offered.

Divisions of the Army Service Forces and Air Forces responsible for termination of contracts and disposition of surplus property were urged by the Occupational Health Division, Army Medical Corps, to consider, in the termination of all contracts, the radium hazard involved and to inform each contractor concerned of the dangers as well as of arrangements made for proper disposal.

The Industrial Hygiene Division, U. S. Public Health Service, is prepared to notify all State and local industrial hygiene units of the potentialities of this problem and of steps they should take in attempting to control this hazard.

Of the many plants which have unused stocks, one plant alone has 10,000 radium painted dials on hand which would contain about 100 mg. radium. There is enough radium in some signal dials to be dangerous if ingested or inhaled by a worker while fumes from a melt containing many radium dials would be extremely perilous.

Attention was brought first to this problem by a plant medical director, who, having found that a number of radium dials had been sold to a salvage dealer as scrap brass, realized the impending danger and notified Dr. Robley Evans of the Massachusetts Institute of Technology. Dr. Evans, director of one of the two laboratories in this country in which radon determinations are made, requested that the entire excess stock be held for safe disposal and in turn notified the War Production Board. The U. S. Public Health Service first heard of this problem through the Massachusetts Division of Occupational Hygiene which has for a long time been active in the control of radium dial painting in various establishments in that State.

Proposals for disposition are under consideration. Unused material may be turned over to a competent laboratory for recovery of the radium with due regard to laboratory safety precautions. An alternative proposal is for the Government to buy up all parts containing radium and dump them at sea.—From the *Industrial Hygiene News Letter*, Vol. 5, May, 1945.

Step Up THE ACCURACY OF YOUR OPERATING EQUIPMENT with *Raytheon Voltage Stabilizers*

LINE VOLTAGE may vary between 95 and 130 volts. If not stabilized at the input side of your equipment, this variation can cause highly inaccurate performance.

Get a close-up of the kind of performance your equipment can deliver when teamed with a magnetic-type Raytheon Voltage Stabilizer. Inquire now.

Raytheon Voltage Stabilizers are at work in such varied fields as:

RADIO • TELEVISION • COMMUNICATIONS • RADAR • MOTION PICTURES • SOUND RECORDING • ELECTRONIC DEVICES • CONSTANT SPEED MOTORS • PRODUCTION MACHINERY • SIGNAL SYSTEMS • X-RAY EQUIPMENT TESTING AND LABORATORY EQUIPMENT

Write today for Stabilizer Bulletin DL48-537. Get the story complete.

- ★ **Control of output voltage to within ±½%.**
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- ★ **Quick response. Stabilizes varying input voltage within 1/20 second.**
- ★ **Entirely automatic. No moving parts. No maintenance. No adjustments.**
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ELECTRICAL EQUIPMENT DIVISION
Excellence in Electronics

VOLTAGE--
BREAKDOWN
Tester

● A simple, positive, safe and quick means of testing D.C. voltage-breakdown on materials or components. Used in the laboratory or out in the plant. Can be operated by usual factory personnel.

- Plugs into standard A.C. outlet. Rectifier provides 1 to 4000 v. (Type P-1 here shown) or 1 to 10,000 v. (P-3 large cabinet type) D.C., continuously variable.
- Red panel light indicates "On" or "live". Variac knob is rotated until meter reads desired test voltage.
- Second panel light indicates when breakdown occurs, and meter gives the breakdown voltage.
- Current-limiting resistors keep current to approximately 5 milliamperes on P-1, or 40 milliamperes on P-3, over full range, as safety measure.

A standard test equipment now available for prompt delivery.

Typical of the large and growing line of "Industrial Instruments"—instrumentation for everyday work about laboratory or production line—practical, dependable, moderate in cost.

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Instruments:

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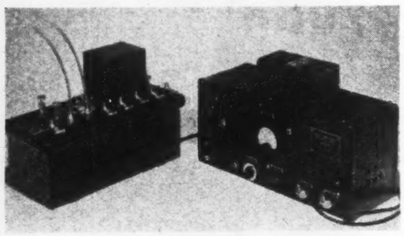
The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions. When writing to manufacturers directly, please mention this department. Or write to Information Section, Instruments Publishing Company.

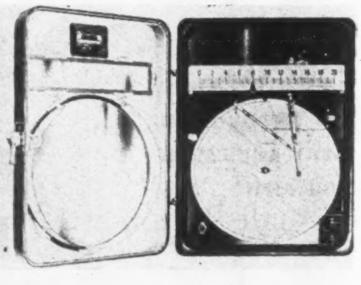
Infra-red Gas Analyzer

New infra-red gas analyzer is a continuous-flow instrument of particular interest to petroleum and chemical industries. It operates on the principle than any change in energy representing an absorption band in the gas is detected by the bolometer, then amplified and recorded. Two balanced infrared beams from a single source are focussed by front-surface mirrors on two bolometer arms which are elements of a Wheatstone bridge. The sample cell is placed in the path of both beams, and a filter cell, containing the gas to be detected, covers one of the beams, making analyzer sensitive only to this gas. Ultimate sensitivity of control type analyzer is better than one part carbon dioxide in 10,000 parts of air. There are four models, which may be adapted to individual problems. The amplifier includes a voltage-regulating transformer for operating several makes of industrial recorders. — *Baird Associates, 33 University Road, Cambridge 38, Mass.*



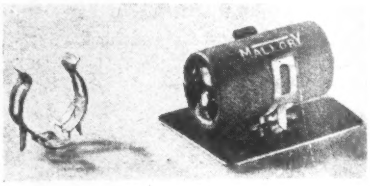
Electric-type Potentiometer Controllers

New series of electric-type potentiometer controllers comprise five basic control unit types. Three are electric types, to be known as the "Microact" controllers; the other two are Electric Proportioning and Current Input types. Units are mounted on the internal panel of "Bristol Pyromaster Potentiometer Recorder" and any type may be readily converted to any other type by following simple wiring and mounting instructions. The three "Microact" units are provided with one, two, and three precision-type toggle switches respectively and six different terminal-board connection arrangements, to meet a wide assortment of control circuit requirements. Proportioning controllers may be used with any type of electric proportioning valve and may be had with resetting contacts if required. Proportional Current Input Controller is primarily designed to provide close temperature control of electric furnaces and ovens.—*The Bristol Company, Waterbury 91, Conn.*



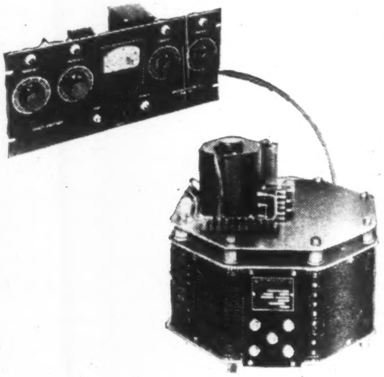
"No-tool" Capacitor Mounting

New Mallory "Type TH" or Prestole "Series 500" capacitor mounting clip requires no tools for assembly. Among other advantages are small space required and simplicity of attaching capacitor. Clip is available in five sizes from ⅝" to 1⅜".—Made by *Prestole Div. Detroit Harvester Co.;* originated and distributed by *P. R. Mallory & Co., Inc., Indianapolis, Indiana.*

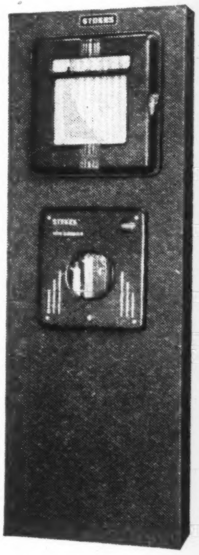


Servo-operated Variable-voltage Transformer

New "Remote Positioner" consists of a motor-operated "Powerstat" variable-voltage transformer and remote-positioning elements which are bridge connected. The output of this bridge is connected to a thyratron relay assembly which energizes the "Powerstat" driving motor until balance is reached. Equipment was developed to fill the need for accurately controlling the plate power to a number of present levels in dielectric heating apparatus. In this application it was desired to use a r-f. generator to alternately heat a number of mold preforms each requiring a different power level. A control circuit is alternately connected to one of four controls in the circuit which causes the output voltage of a motor-operated "Powerstat" variable transformer to increase from zero to a voltage indicated



by the control dial. Connection to another control or resetting of control in circuit causes a corresponding change to take place in the "Powerstat" output voltage. Circuit is arranged so that this change of voltage is accomplished either by reducing to zero voltage and increasing to the new value or by continuous change to the new value without reducing to zero. Any "Powerstat" variable voltage transformer from ½ to 100 kva. may operate with new Remote Positioner. *Superior Electric Co., Bristol, Conn.*



High-vacuum Recorder

(*Instruments*, July 1945, pages 510-512).

CORRECTION—The wrong illustration had been sent to *Instruments*. Herewith is the correct one.

Improved Electrical Instruments

New improvements, affecting maker's entire line of indicating electrical instruments, consist mostly in greatly increased shock-resistance. Only a brief summary can be given. (1) "Types TD, TA, RD and RA" ammeters and voltmeters—see Fig. 1—have been improved as follows: Movements are now mounted on a base of BM1132 High-impact Bakelite. (They were formerly mounted on ordinary synthetic material.) Also, method of locking the current-carrying mounting studs into this Bakelite base has been improved: formerly bolted through in conventional manner, stud is now of such shape that it cannot turn, is practically locked into Bakelite base and all possibility of twisting motion that might disconnect the instrument electrically has been eliminated. (2) Portable "Types DD, DA, OD, OA, PD, PA, VD, VA and VD Special" ammeters and voltmeters—see Fig. 2—have been improved by substitution of synthetic rubber mounts for the movements in place of the rigid metal mounts that were formerly used. One

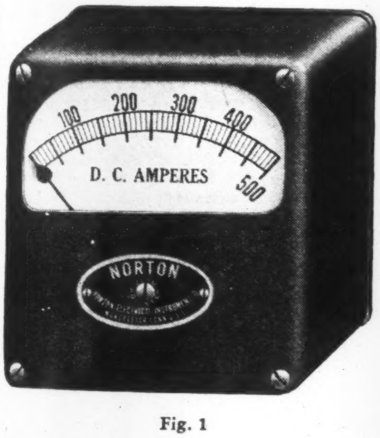
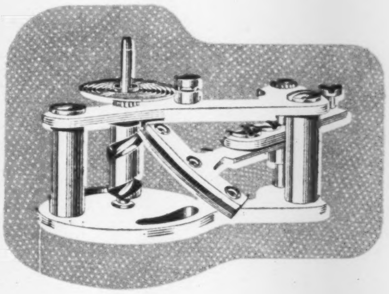


Fig. 1



DO YOU HAVE SUDDEN SHOCKS?

If you have pressure gauges which are subject to sudden shocks on releases of pressure, then Certified are the gauges for you. On hydraulic presses, the sudden release of pressure just about ruins the ordinary gauge with geared teeth.

But with Certified Gauges, a sudden release of pressure merely releases the cam from the Helicoid movement roller and that's that. No harm can come to the gauge. The force of the pointer against the stop pin is only that exerted by the hair spring. You get the same protection if your pressure gauges are subjected to vacuum as on turbine and condenser service. This is possible only with the Helicoid movement. And the Helicoid movement is used only in Certified Gauges.

All Certified Gauges are guaranteed accurate to within ½ of 1% of the scale range. They remain accurate longer.

9-CG-5

ARMY E NAVY

Certified GAUGE
AND INSTRUMENT CORP.

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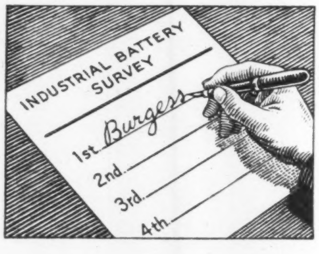
PORTABLE POWER PROBLEMS

THIS MONTH—ILG MOTOR TEMPERATURE TEST

BURGESS INDUSTRIAL BATTERIES power ohmmeters to determine temperature rise in fan motors manufactured by Ilg Electric Ventilating Company. Thousands of industries using test and control equipment rely on Burgess Batteries for dependable service. Your local Burgess distributor can fill your needs from the line designed to meet industrial battery requirements. For full information on the *complete line* of dry batteries write for the name and address of your nearest Burgess distributor now.

2 OUT OF 3 SELECTED BURGESS BATTERIES as their *first choice* in a recent nation-wide survey of manufacturer electronic engineers. If you require a special battery for a new application, Burgess engineers can solve your problem with the right battery type. *Burgess Battery Company, Freeport, Ill.*



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BURGESS
45 VOLT "B"
BATTERY
BURGESS BATTERY COMPANY

BURGESS BATTERIES

LOOSE TALK IS STILL DANGEROUS!

Recognized as the MOST COMPLETE LINE of dry batteries

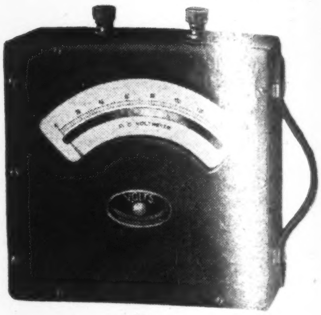
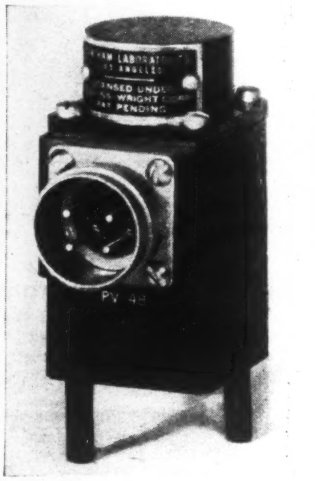


Fig. 2

can readily understand importance of this improvement in a sensitive instrument mounted in a portable carrying case.—*The Norton Electrical Instrument Co., Dep't 83, Manchester, Conn.*

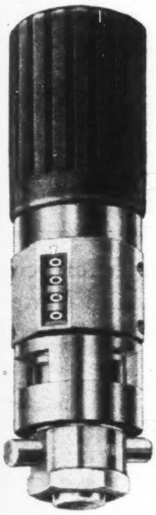
Pressure Transmitters

New "Model PV" Pressure Transmitters, available in ranges from ±½ to ±50 lbs./in.^{2} for use as primary elements in indicating and recording dynamic and static pressures of air or liquids, operate from simple batteries direct to the indicating or recording instruments. In most applications, no amplification is required. Sensitive element of these Pressure Transmitters employs the unbonded strain-sensitive filament technique developed by the manufacturer. The bridge is connected and permanently balanced inside the instrument. Linearity, accuracy and permanence of calibration are dependable within 2%. Zero is independent of ambient temperatures, and calibration factor is altered less than 4% by reducing the ambient temperature to −65°F. "Model PV" can be supplied with two pressure inlets for differential pressure measurement, or with a single pressure inlet and either vacuum or atmospheric reference. Weight 3 oz. Dimensions 1¼" × 1¼" × 2½".—*Statham Laboratories, 8222 Beverly Blvd., Los Angeles 36, Calif.*



Diesel Engine Pressure Indicator

New simplified "Premax Model Y[illegible]A Engine Pressure Indicator" for direct-reading of compression and firing pressures of any type of diesel engine at any engine speed or rate of pressure rise, is designed so that counter locks automatically when maximum pressure in cylinder shows on dial. This unique feature makes practically impossible a mistake in reading. Another feature is that only one figure appears in window of counter, and this figure represents actual maximum engine pressure in lbs./in.^{2}. Operation is based on principle of balancing maximum cylinder pressure by the force of a precisely-calibrated helical spring, and then measur-ng deflecti of spring. Tension of spring is ncreased rotating vulcanized handle of instrument ckwise, and decreased by turning it cou -clockwise. Handle rotation is synchroniz with the counter. In taking a reading, lle is turned clockwise until counter is slightly in excess of expected maximum nder pressure. Then, by rotating handl ounter-clockwise, spring pressure is r ced until maximum cylinder pressure offsets it. At this instant, latch



nechanism of instrument locks handle firmly n position, giving signal to read counter. Successive pressure readings may be taken apidly since no venting is required between eadings. According to manufacturer, preise factory calibration of instrument is pernanent even if it is exposed to over-presure, shock, or exceptionally severe usage. In a recent test it is reported that "Model YRF Indicator" was kept on an engine to heck firing pressure approximately 500 imes within eight hours, yet at end of test, alibration was found to be practically unhanged. "YRF Indicator" may be used to ndicate cylinder pressure up to 1700 lbs./n.2. No adjustment or settings are required n the field to compensate for instrument haracteristics, purpose of test, or engine onditions — *Bacharach Industrial Instrunent Co., 7000 Bennett St., Pittsburgh 8, Penna.*

Resistance Limit Bridge

New "Model LB-3" resistance limit bridge working to ±0.1% is a modified Wheatstone bridge with high and low limit dials covering a range of ±11% in 0.1% steps, and a sensitive built-in galvanometer to provide for the high and low indication, respectively. In normal operating position, zero on galvanometer scale acts as a reference point. Relays incorporated in instru-

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AVAILABLE IN 2½"—3½"—4¼" ROUND STYLES
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Now, you can get HICKOK precision and dependability in a new line of hermetically sealed meters. Available in 2½", 3½" and 4¼" round styles. Dimensions of American War Standards Assn. Drawings C39.2-1 and C39.2-2. The 4¼" size is built especially for use in radio service equipment where several scale arcs are required.

All instruments are hermetically sealed and both vacuum and pressure tested under water. Case fabricated of pressed steel and made corrosion resistant to meet specifications. Terminals are a special glass soldered-in type.

All meters are fully shielded, permitting use on either magnetic or non-magnetic panels. Operation is accurate and dependable even up to 85° centigrade. Internal pivot construction in D.C. types assures longer life and greater resistance to shock and vibration. Write for further information today.

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ment provide for speedy test operation, either from a switch on panel or built into test fixture. A receptacle on panel provides connections between external switch and internal relays. New bridge may be used to check resistors between 1 ohm and [illegible] megohms. External resistance standards corresponding to nominal values of resistors under test, are required. For most measurements, galvanometer and internal 3-volt d.c. source will be found satisfactory. For measurement of resistors above several thousand ohms and particularly when resistance range is increased above 1 megohm, an external battery is recommended. For low resistance measurements particularly below 10 ohms, a more sensitive external galvanometer may be desirable, although most measurements between 1 and 10 ohms may be satisfactorily made by using an external 1½-volt battery. —*Industrial Instruments, Inc., 17 Pollock Ave., Jersey City 5, N. J.*

Polarizing Microscopes with Polaroid Material

Within a short time, undersigned company expects to supply a specially selected grade of Polaroid in some polarizing microscope models. Extensive tests, both with the spectrophotometer and by experts in the field, have shown the selected material to be completely satisfactory. Because of the reduced thickness of Polaroid over the calcite prisms previously used, important design changes in polarizing microscopes are possible. These include simplification of the substage, and the omission of the astigmatizing lenses, together with a shortening of the tube above the objectives. In practice, the simplification of the instruments is expected to contribute to economy and working convenience.—*Bausch & Lomb Optical Co., 663 St. Paul St., Rochester 2, N. Y.*

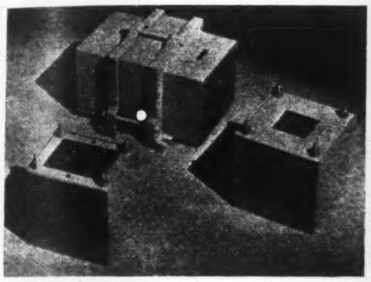
Portable Hardness Testing Hammer

New "Type P Portable Hardness Testing Hammer" makes practical the taking of a hardness test where the material is, in the shop, yard, on the truck, car, etc., employing

any unskilled labor. Repeated tests can be made without readjusting the hammer. If material of a certain degree of hardness is to be selected, it is only necessary to see whether diameter of impression corresponds to desired degree of hardness. This is done with microscope and chart supplied. Tester consists of a cylindrical housing and easy moving piston; housing is closed on one end with an inside thread cover, and on the other end with an open bushing. Between cover and piston, a strong spring is located which presses piston against bushing. Tension of spring can be adjusted by turning cover, if hammer is to be set a certain power of stroke. Piston is coupled with a striking piston, which projects through bore of bushing guided by an air-tight fitting ring in cylinder and carrying a steel ball on the end. Resting the hammer with ball against material to be tested, and pressing on operating end, striking piston and piston in housing moves inward and presses against the spring between piston and cover. At a certain point, in this movement, the coupling between piston and striking bolt is released, so that piston, under pressure of spring, moves against inner end of striking bolt and ball, striking against the material to be tested. After hammer is released, striking bolt or piston is brought back to its former position by a spring in cylinder. Cushion of compressed air before guiding ring causes a slow backward movement of the ball, and prevents spoiling the impression made.—*Steel City Testing Laboratory, 8843 Livernois Ave., Detroit 4, Mich.*

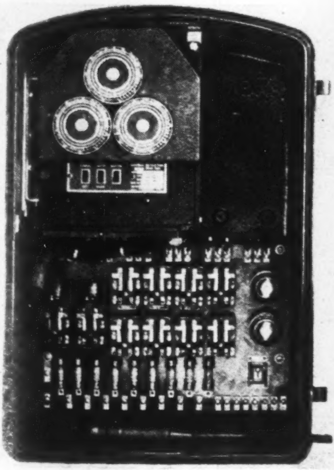
Autotransformers

Three new continuous-duty autotransformers incorporate heavy lugs on black Bakelite terminal boards. Types "800" and "801" are also available in hermetically sealed units to Army-Navy specifications. They are as follows: "Type 800-A" primary 220 volts, 60 cycles; secondary 110 volts, 250 watts; 5AS case, length 4 1/16", width 3 13/16", height 5". Weight 10 lbs. "Type 801-A"—primary 220 volts, 60 cycles; secondary 110 volts, 500 watts; 6AS case, length 5 1/16", width 4 13/16", height 5". Weight 16 lbs. "Type 802-A"—primary 220 volts, 60 cycles; secondary 110 volts, 1000 watts; housed in No. 6 casting poured with humidity-proof compound, length 9¼", width 7¼", height 6¾". Weight 33 lbs. Units are available for immediate delivery from New York. — *The Langevin Co., Inc., 37 West 65th Street, New York 23, N. Y.*



Multi-dial Traffic Controller

New multi-dial traffic controller permits automatic changing of signal-interval lengths to correspond with changes in volume of main and cross-street intersecting traffic. Length of a pedestrian interval can also be changed to correspond with changes in pe-



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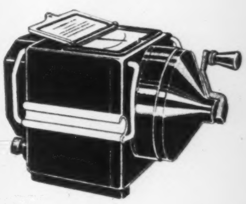
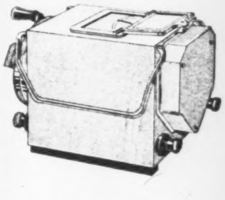
The registered trade-mark "Megger" is not the name of any single device; it is neither adjective nor noun; of itself, it has no generic or descriptive meaning. "Megger" is simply the mark or symbol identifying a specific brand of insulation testers, megohmmeters, ground testers, ohmmeters and other measuring and testing devices.



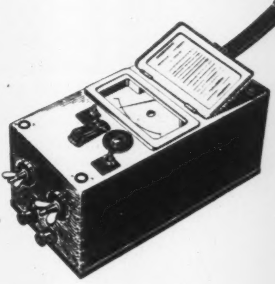
"Megger" Insulation Testers

"Meg," "Super-Meg" and Midget types to meet practically all requirements for testing insulation resistance of electrical equipment. Ratings up to 2000 megohms and 1000 volts d-c. Hand-cranked generators always ready for use. 500-volt models are most popular. *Bulletins 1735-I and 1785-I.*



"Megger" Ground Testers

Undoubtedly the most simple and reliable devices ever developed for measuring resistance to earth of ground rods, metal structures and other ground connections. Hand-cranked generators. Ranges as low as 0 to 3 ohms and as high as 0 to 30,000 ohms. *Catalog 1645-I.*



"Megger" Ohmmeters

Illustrated is the low resistance "Ducter" type for switch, circuit breaker and contact resistances, direct indicating down to .000001 ohm. Operated by storage battery. "Ducter" measurements identify incipient trouble and forestall failure. *Bulletin 1635-I.*

★ Three important electrical maintenance tools . . . direct indicating . . . simple to operate . . . rugged and highly dependable . . . generally accepted for maximum reliability and economy in field use.

Let us explain why and how "Megger" instruments are used in testing and maintenance work; why there is a place for them in nearly every electrical equipment maintenance routine.

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Due to design characteristics and close control of manufacturing processes, Burlington instruments embody the following advantages:

PERMANENCE OF CALIBRATION . . . All DC instruments employ Alnico magnets which are known to be more highly resistant to shock, heat, vibration, and stray fields than any other magnetic material.

FREEDOM FROM STICKING . . . Clearances for all moving parts are such that the results of entrance of small particles as encountered in field service are reduced to a minimum.

STABILITY OF OPERATION . . . All instruments are "NORMALIZED" after assembly to eliminate "zero shift" and other calibration errors due to ageing.

Exceptionally high torque to weight ratio of control springs to moving element insures minimum error under conditions of shock, vibration, and other rough usage.

Alignment of jewels and magnet core piece is such that the center lines of these parts coincide within plus or minus .002". The design of the brass movement frame and components is such that mechanical tolerances are reduced to a minimum in assembly. As a result, jewel and pivot wear is uniform which reduces "frictional torque" of the moving coil.

All series resistors and coils are heat treated and impregnated after wrapping to insure stability and long life.

All ranges AC & DC are available in 2½", 3½" and 4½" sizes, both square and round, flush mounting.

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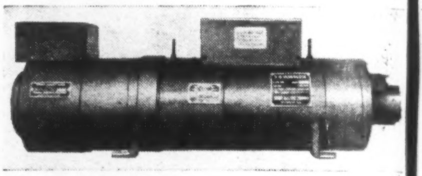
PANEL INSTRUMENTS • VOLTAGE REGULATORS • AUTOMATIC SYNCHRONIZERS • FREQUENCY REGULATORS

destrian volume. New controllers, available with two or three dials, come in two types, one for isolated intersections and the other for use with single- or other multi-dial controllers in an interconnected system. Each dial is pre-set for a different traffic condition. When predetermined condition occurs, a time switch automatically puts correct dial into operation. A manual switch on controller panel can be used for selecting any of the dials when an unexpected traffic change occurs. In an interconnected system, new device can be used with simple reset and remote-cycle change regardless of which dial is operating. Each dial has its own dial-contact block, contacts operating various controller elements in the same manner as in a single-dial controller. A gear system allows driving motor to turn all dials synchronously at the same speed. As in standard controllers, all parts are large and widely spaced for ready access. Basic design is similar to that of other G-E controllers, with the same parts and sub-assemblies.—*Lighting Division, General Electric Co., Schenectady 5, New York.*

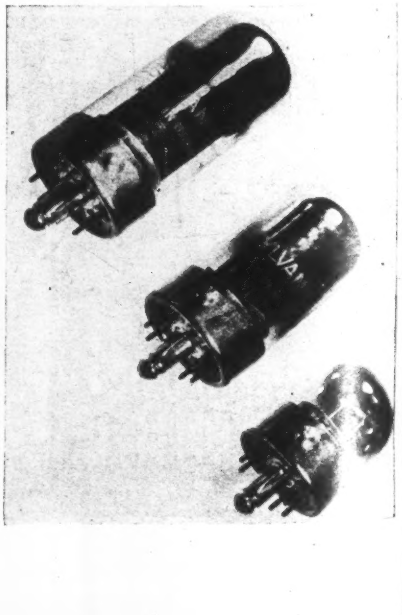
Motor-generator Set

New ultra light weight and space-saving, sealed type two-bearing motor-generator set is specially constructed for applications where many d-c. voltages are required. New unit has no sub base as is required by ordinary multiple-unit motor-generator sets. Of drip-proof and shock-proof type, it is semi-enclosed and has five commutators and pair of slip rings. It is built for d-c. operation but can be furnished with either d-c. or a-c. driving motors. It provides a-c. voltages and several different specified d-c. voltages from 12 to 2000 volts, and is said to have fine voltage regulation and to meet low ripple requirements. Special terminal boards are contained in a shockproof housing mounted on top of unit for easy accessibility. Sealed-type bearings require practically no attention.—*Bogue Electric Co., 40 Kentucky Ave., Paterson 3, N. J.*



"Lock-in" Electron Tubes

New "lock-in" electron tubes feature sturdy mechanical construction to withstand vibration, shock and rough service in aircraft, automotive and industrial appli-



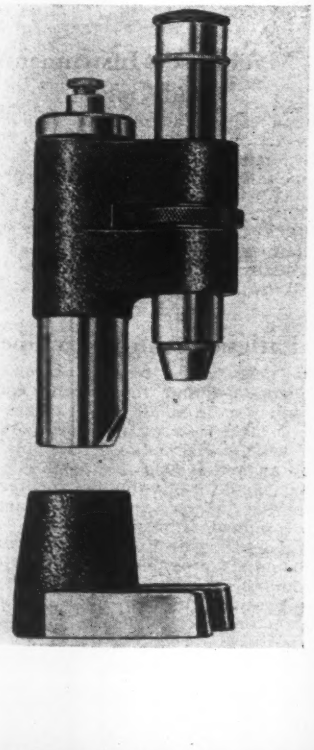
cations of radio and electronic control; also provide many electrical advantages for high- and ultra-high-frequency applications. Tube bases of all-metal design provide shock-proof positioning of tube in its socket. Solid socket pins, which provide excellent mechanical and electrical contacts with socket pins, are welded directly to tube elements, utilizing glass "header" construction permitting use of heavier element supports, direct bonding of pins to glass and more durable glass envelope construction, lock-in The design also substantially reduces the inductance and interelement capacitances. — *Commercial Engineering Dep't, Sylvania Electric Products, Inc., Emporium, Penna.*

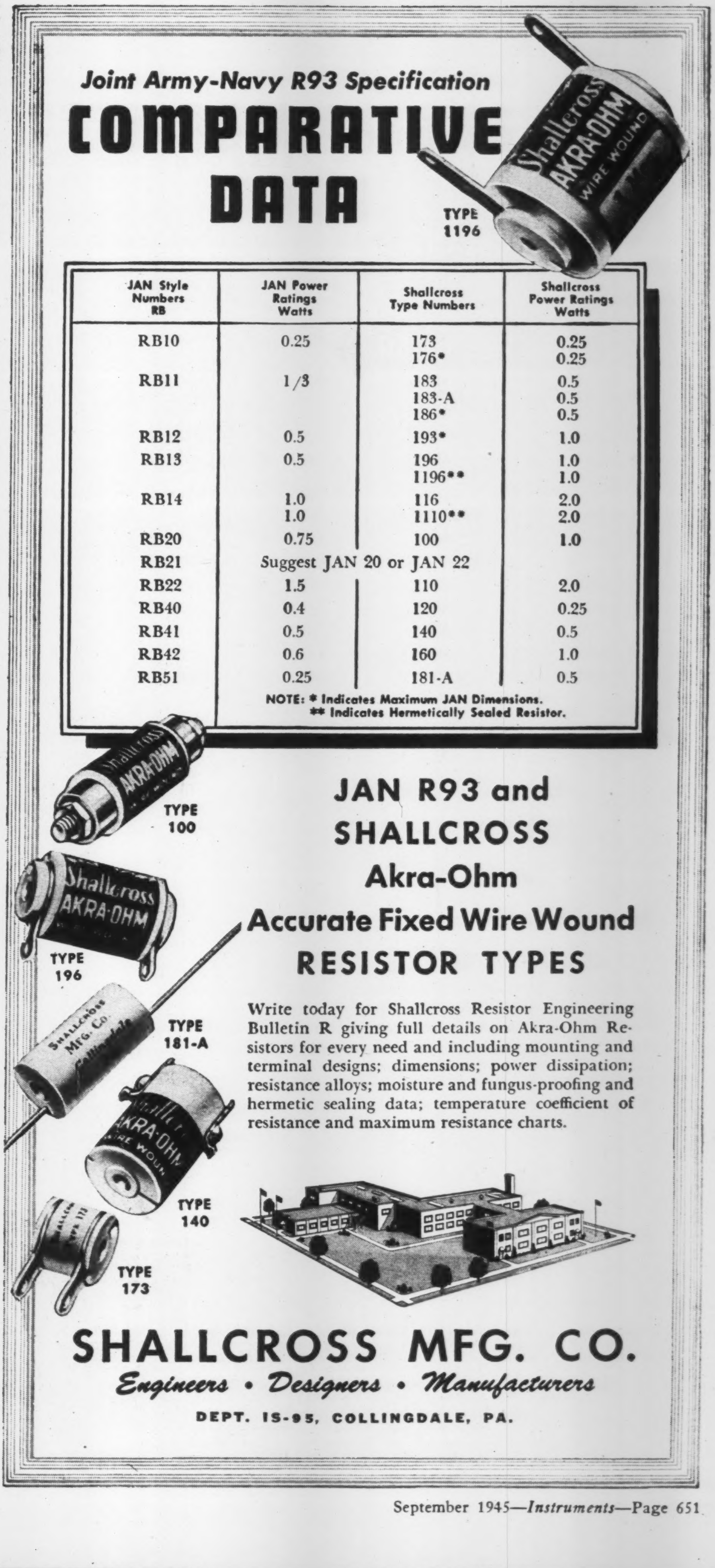
Angular Accelerometer Unit

New highly-sensitive angular accelerometer unit is designed for measuring pitch, roll, or yaw accelerations of airplanes, ships, locomotives, automobiles and other vehicles. Unit includes an iron core which moves with respect to the coils of a differential transformer (in contrast to conventional system of two-arms-of-a-bridge that requires external balancing units). Unit does not require external balancing, but conventional bridge system can be used if desired. Unit is 5½" long, 1⅛" wide, and 3" high. It weighs 1¾ lbs. Natural frequencies are 14, 18, and 22 c.p.s. Higher frequencies can be obtained by simple substitution of a spring. Carrier frequencies up to 30,000 c.p.s. have been used. At a natural frequency of 14 c.p.s., output is 700 microvolts/radian sec.^{2} for an input of 1 volt. Calibration is linear to plus or minus 30 radians/sec.^{2}. New accelerometer is used with a conventional strain gage and acceleration measuring equipment, or, alternately (1) with oscillator, a pick-up, copper oxide rectifier, and high-sensitivity galvanometer; (2) with oscillator, a pick-up, and rectifier type indicator for visual or photographic purposes. Accuracy is ± 0.1 radian/sec.^{2} as measured by carrier amplifier and oscillograph having a sensitivity of a 2 radians/sec.^{2}/inch deflection. Response to linear vibrations and accelerations of all frequencies is negligible. There is no zero drift over a temperature range of 100°F. to —30°F.—*Trimount Instrument Company, 37 W. Van Buren St., Chicago 5, Illinois.*

Shop Microscopes

New Polan Shop Microscopes, designed to bring precise optical measurement to the machine industry, are constructed to withstand the abuse which cannot be avoided in





Joint Army-Navy R93 Specification

COMPARATIVE DATA

TYPE 1196
Shallcross
AKRA-OHM
WIRE WOUND

JAN Style Numbers RB	JAN Power Ratings Watts	Shallcross Type Numbers	Shallcross Power Ratings Watts
RB10	0.25	173 176*	0.25 0.25
RB11	1/3	183 183-A 186*	0.5 0.5 0.5
RB12	0.5	193*	1.0
RB13	0.5	196 1196**	1.0 1.0
RB14	1.0 1.0	116 1110**	2.0 2.0
RB20	0.75	100	1.0
RB21	Suggest JAN 20 or JAN 22		
RB22	1.5	110	2.0
RB40	0.4	120	0.25
RB41	0.5	140	0.5
RB42	0.6	160	1.0
RB51	0.25	181-A	0.5

NOTE: * Indicates Maximum JAN Dimensions.
** Indicates Hermetically Sealed Resistor.

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Write today for Shallcross Resistor Engineering Bulletin R giving full details on Akra-Ohm Resistors for every need and including mounting and terminal designs; dimensions; power dissipation; resistance alloys; moisture and fungus-proofing and hermetic sealing data; temperature coefficient of resistance and maximum resistance charts.

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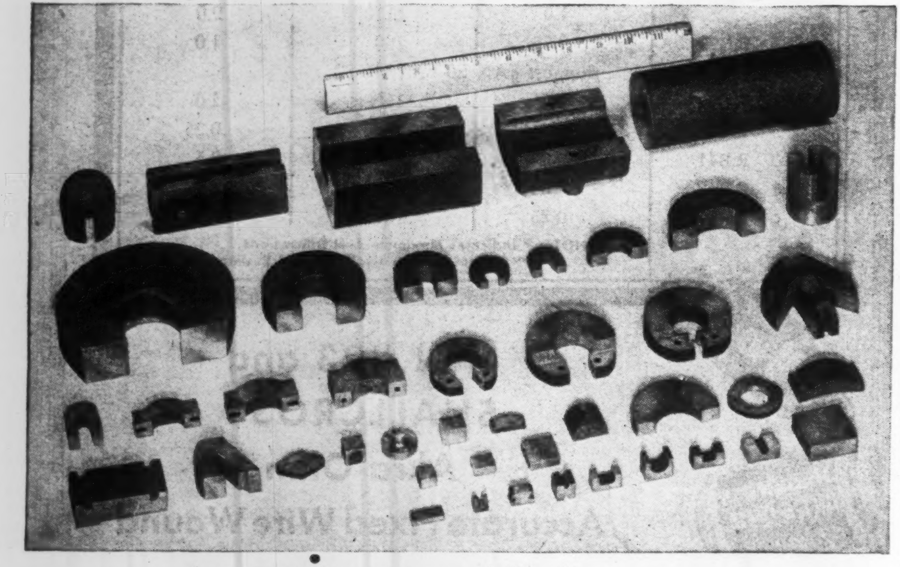

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shop practice. Standard reticle permits accurate measurement to 0.001" and to ± 0.0002" by estimation. Instrument may be equipped with reticle having special designs for contour inspections or measurements of specific tolerances on tools or parts. Built-in illumination consists of easily-acquired flashlight bulb and cells. 16.7-power Kellner eyepiece and 3-power achromatic objective give an over-all magnification of 50-power which is adequate for normal inspection of machine parts. New Shop Microscope is equipped with separate removable base, bottom and sides of which are ground flat. Parallel sides, which are ⅞" from optical center, have ground surfaces which make it possible to use instrument with gage blocks and measuring wires. Bottom surface has a prismatic groove which optically centers instrument on round rods or curved surfaces of machines.—*Polan Industries, Huntington 19, W. Va.*

Machine Running-time Recorder

New instrument for recording machine running-time and checking machine performance records operating or "on" time of production machinery and other similar equipment.

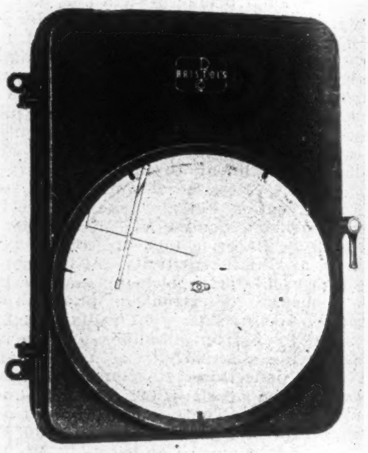

Chart record gives total "on" time in hours, minutes, and seconds for a given period. "Off" periods are also shown on chart as well as time at which they occurred. Running-time readings are magnified in such a way that total operating time of a machine can be easily and accurately determined to within a few seconds.—*The Bristol Company, Waterbury 91, Conn.*

Machinist's Instruments and Gages

New complete line of machinist instruments and gages includes: Depth Micrometers, Surface Gages, Screw Pitch Gages, Thickness Gages, Engineers' Gages including Wire, Thickness and Taper Blades, and Drill and Wire Gages. This new popularly-priced line is available from stock and through distributors nationally. It is being manufactured by the *Products Engineering Co., 9045 Wilshire Blvd., Beverly Hills, Calif.*

Fatigue-testing Machines

Two new fatigue-testing machines meet increasing demand for testing equipment that will handle small pieces or sub-assemblies of larger structures, incorporate features which will make it possible to approach an actual field test much closer than before, should be valuable for testing of automotive and airplane parts or any structural components or specimens.

(1) "Southwark Universal Fatigue Testing Machine" provides a dynamic load application of 20,000 lbs. in one direction, is made possible through hydraulic preloading attachment of 10,000-lb. capacity. High

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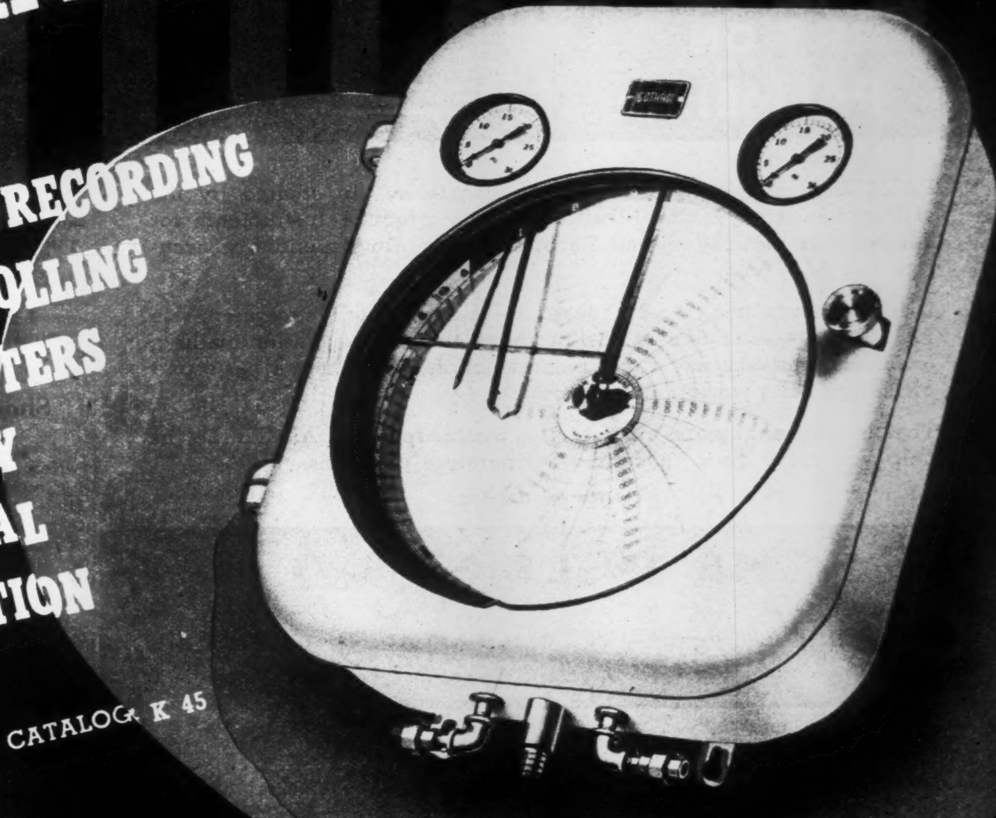

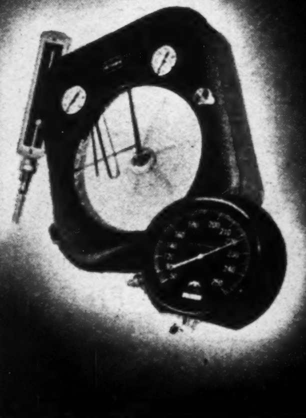

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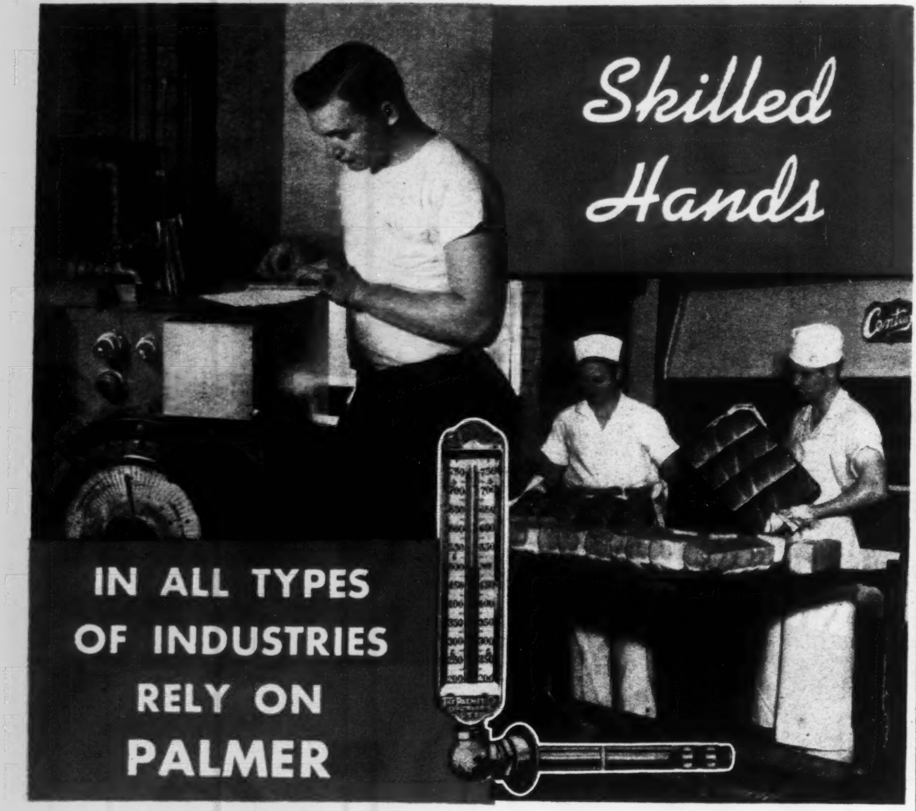
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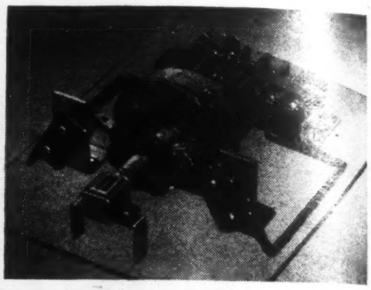
operating speed (approx. 2,000 load cycles per minute) and constant force as opposed to constant deflection, are important advantages. Any predetermined alternating load is kept automatically constant regardless of changes of deflection in specimen under test. Accessory tools for testing various sizes and shapes of specimens in tension or compression, bending or torsion, are available. Standard distance between plates is 48" but machine can easily be adjusted for longer specimens. Dynamic load is produced by a centrifugal force type oscillator, the force of which is amplified by working near resonance of system. Load is measured and controlled electronically. Maximum alternating force is ± 10,000 lbs. which may be applied in increments of 10 lbs.

(2) Universal Fatigue Testing Machine of 1,000-lb. alternating force capacity likewise has a static preloading attachment which results in a force capacity of 2,000 lbs. in one direction. It was developed for tests in tension-compression, bending or torsion. Torsion testing attachments have a capacity up to 30,000 inch pounds and permit testing of specimens exceeding 1" in in diameter. Standard tension-compression fixture for testing specimens is equipped with tapered collets to grip plain cylindrical pieces. Bending fixtures are available up to 6,000 inch pounds bending moment for testing flat plate specimens up to approx. ⅜" in steel, ½" in aluminum alloys and 1" in plastics. Like the other new machine, this 1,000-lb. tester operates at high speed and may be set for any predetermined alternating load which is then automatically kept constant. An inertia force compensator of simple construction cancels all inertia forces, and accuracy of loads transmitted is kept well within ±2%. Entire mechanism of machine, including large T-slotted worktable attached for use in tes[illegible] assemblies, structure components or part[illegible] seismically suspended in the frame to el[illegible] ate transmission of vibration to flo[illegible] Southwark *Div., Baldwin Locomotive* W[illegible] *Philadelphia 42, Penna.*

Timing Contact

New timing contactor, for [illegible] testing electrically-operated mechanis[illegible] ch as solenoids, relays, etc., partic[illegible] where break-down or life tests are [illegible] l, con-



sists of a synchronous motor (available in various speeds) and two Micro Switches operated by a cam disk fastened to motor shaft. It can be operated continuously "for an indefinite period of time" and requires no attention. Desired number of makes and breaks per minute is obtained by using disks with various numbers of cams, and motors of various speeds. While new unit is particularly valuable in running "destruction tests," it can also be used where contacts are to be opened and closed regularly. Terminals are provided for easy wire connections, and two switches are standard equipment so that two tests can be run at the same time. A counter, for short runs, is optional. Unit is portable, may be plugged in anywhere, has no tubes and no intermediate contactors are necessary. All items are mounted on a steel back plate and come enclosed in a 9" × 12" × 4" sheet metal case finished in black wrinkle enamel. — *B/W Controller Corp., Birmingham, Mich.*

Shock-absorbing Feature for Dial Indicators

New "Cushioned Movement" shock-absorbing mechanism has been built into Federal Dial Indicators after exhaustive practical tests had been made on all available types of shock-absorbing mechanisms as applied to dial indicators. Function of "Cushioned Movement" is to absorb impact of sharp blows or rough handling, so that their force

FEDERAL
0
5
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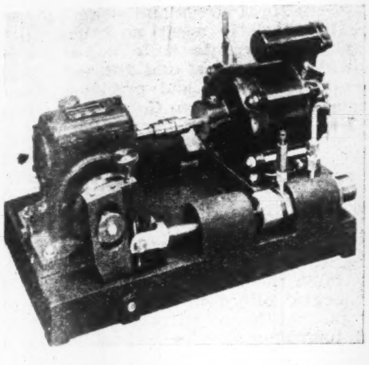
15
WORK PIECE

is cushioned before it reaches small gear teeth, jewels, pivots or other intricate parts of indicator mechanism itself. Federal Indicator movement has not been altered, nor is size and appearance of instrument changed. All regular Improved Movement Federal Indicators having A.G.D. range in C, D & E sizes (English Dials) and P, Q & R sizes (Metric Dials) can now be furnished with new "Cushioned Movement." Exceptions are "Models E3BS and Q6IS." Regular Federal Dial Indicators now in use (except B sizes) may be returned to Federal for the purpose of installing new "Cushioned Movement" at a nominal cost.—*Federal Products Corp., 1144 Eddy St., Providence 1, R. I.*

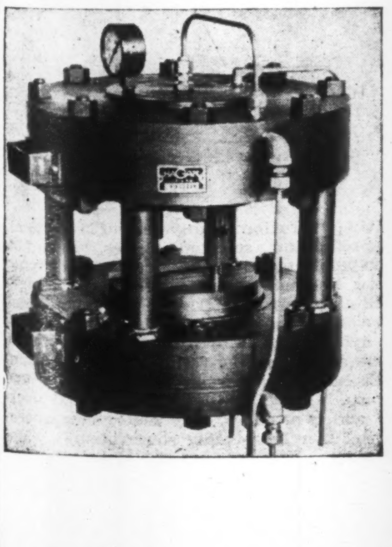
High-speed Duplex Pump for Experimental Work, etc.

New "Precision-U.O.P. Duplex High Pressure Pump, Variable Stroke," meets requirements for a sturdy, continuous-duty, high-pressure, adjustable-stroke pump for use in experimental pressure work, pilot plant operations and many industrial applications. Developed in collaboration with the Universal Oil Products Co., new pump is of duplex type, with individual cylinders permitting two different types of liquids to be pumped simultaneously, or, where increased volume is desired above the capacity of a single cylinder, both cylinders can be piped in parallel. Because of compact design, these pumps are particularly adaptable to most applications where space is at a premium. Design permits continuous operation and pump will maintain a given flow rate continuously, delivering full rated output at maximum rated pressure. Volumetric efficiency throughout full range is over 90%.—*Precision Scientific Co., 1754 North Springfield Ave., Chicago 47, Illinois.*

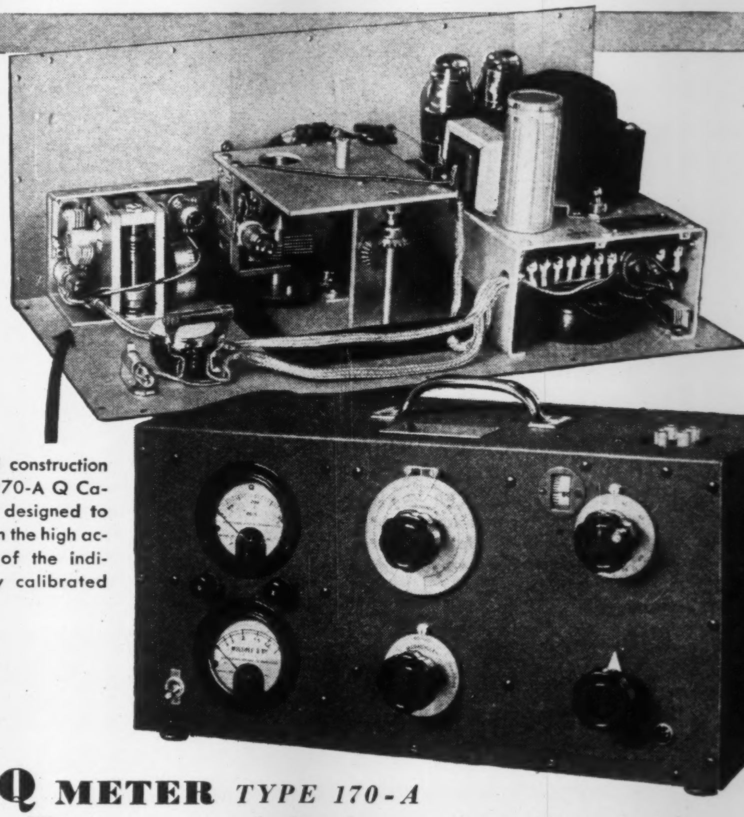


Pneumatic Unit for Measuring Forces, Strains, etc.

New "Thrustorq" for measuring and weighing with air is said to be "so accurate and sensitive that it will measure the force of a pea from a boy's peashooter or the



DEPENDABLE performance and durability of a Test Instrument is assured by its design and sturdiness of construction. All B. R. C. instruments are ruggedly built to give exacting and precise direct reading measurements with simplicity of operation.



Rugged construction of the 170-A Q Capacitor designed to maintain the high accuracy of the individually calibrated dial.

Q METER *TYPE 170-A*

This instrument embodies the general operating principles and characteristics of the 160-A Q-Meter but with such design and structural modifications as are required for accurate performance at higher frequencies. Has a frequency range of 30 mc to 200 mc.

Q METER *TYPE 160-A*—A standard for "Q" measurements with a reputation for accurate and dependable service. Has a frequency range of 50 kc to 75 mc which may be extended with external oscillator down to 1 kc.

BOONTON RADIO *Corporation*

BOONTON, N. J.

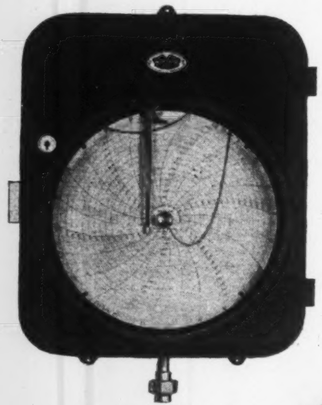
DESIGNERS AND MANUFACTURERS OF THE "Q" METER . . . QX-CHECKER . . . FREQUENCY MODULATED SIGNAL GENERATOR . . . BEAT FREQUENCY GENERATOR . . . AND OTHER DIRECT READING TEST INSTRUMENTS

INSTRUMENTS FOR INDUSTRY

Weksler Gauges

WEKSLER offers to Industry *another* valuable service—a complete line of ruggedly constructed and lastingly accurate Pressure, Compound, Ammonia, Freon, Altitude, Retard, High Pressure and Hydraulic and Recording Gauges—in all Standard Ranges and in the cases and with the various dial sizes listed below.

Pressure Gauge, Phenol Case



Recording Gauge

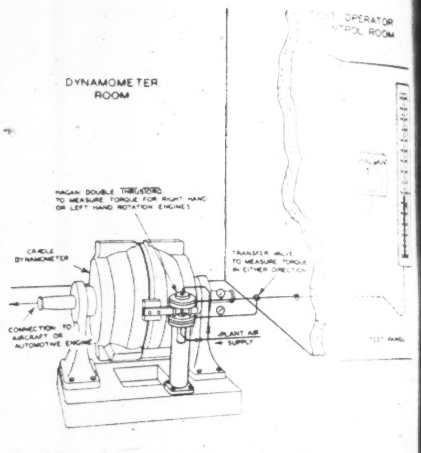
DIAL INDICATING CASES:
PHENOL CONDENSATE
CAST ALUMINUM CAST BRASS
DIAL SIZES: 3½", 4½", 6" and 8½"
RECORDING CASE: CAST ALUMINUM
CHART SIZES: 10" and 12".

Your inquiries as to WEKSLER GAUGES—types of movements, connections, list prices, etc., are solicited. The helpful advice of our Engineering Department is yours for the asking.

Compound Gauge, Cast Brass Case

WEKSLER THERMOMETER CORP.
52-56 West Houston Street
NEW YORK 12, NEW YORK

thrust of a giant jet airplane engine." It is characterized also by simplicity of both principle and design. Heart of new pneumatic unit is a flexible diaphragm which forms one face of an air-tight chamber. Compressed air is admitted to this chamber through a poppet type pilot valve. Force to be measured is applied to outside of diaphragm and is opposed by internal pressure. As force increases, pilot valve is opened and admits more air to balance increased force. As force decreases, air is exhausted until external force and internal pressure are equal. Thus, air pressure within chamber provides a direct measure of externally-applied force. Response of instrument is practically instantaneous because diaphragm movement necessary to operate pilot valve is extremely small. Since force is measured by air pressure, "Thrustorq" permits remote reading on any number of indicating or recording pressure instruments. Every person connected with a test may have his own recorder in front of him, even in a different room or different building from that in which the test is being made. Absence of intricate mechanisms, knife edges or other parts subject to wear, is said to eliminate maintenance entirely. Since "Thrustorq" will function in any position it is being adopted by a manufacturer to measure torque of vertical helicopter engines. Heretofore, some conventional torque-measuring devices required complicated mechanical linkage that brought on attendant maintenance problems. Illustration shows "No. 60 *Double* Thrustorq" for this application. Although first application of "Thrustorq" in industry was the obvious one, to measure thrust and torque of engines, its characteristics suggest many other uses. Because it is compact and requires almost no deflection to provide a



OPERATOR
TROL ROOM
DYNAMOMETER ROOM
HAGAN DOUBLE THRUSTORQ TO MEASURE TORQUE FOR RIGHT HAND OR LEFT HAND ROTATION ENGINES
CRADLE DYNAMOMETER
TRANSFER VALVE TO MEASURE TORQUE IN EITHER DIRECTION
CONNECTION TO AIRCRAFT OR AUTOMOTIVE ENGINE
PLANT AIR SUPPLY
HAGAN
TEST PANEL

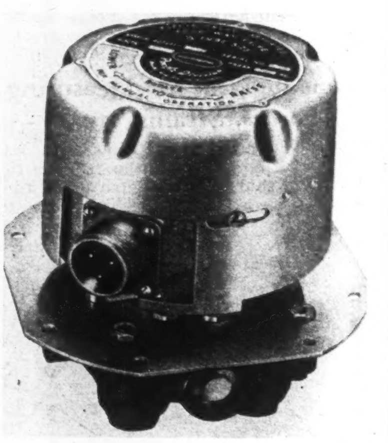
reading of force, unit can be used to analyze many structural stress and strain problems. Once installed, it needs no attendant. Its construction permits it to be used under conditions where dust and dirt and cramped quarters previously had precluded making measurements.—*Hagan Corp., Hagan Bldg., 323 Fourth Ave., Pittsburgh, Penna.*

Unmounted Assemblies for Industrial Instruments

New assemblies, comprising handles and parts, furnished unmounted so purchasers can attach them according to individual requirements, afford increased user convenience through improved portability of industrial instruments. Two assemblies will be available. These will consist of: (1) A cast carrying handle, plus parts, for smaller instruments such as indicators and gages. (2) Two locker type carrying handles, with feet and necessary assembly parts for heavier potentiometer types, including electronic.—*Brown Instrument Co., 4482 Wayne Ave., Philadelphia 44, Penna.*

Electrically-operated Hydraulic Selector Valves

New "Motordyne" series meets growing demand for simple electrically-actuated hydraulic selector valves for remote operation. A rugged electrical actuator provides fast, positive operation of any one of five standard-production selector valves. Manufacturer points out that these new "Motordyne" valves are *not* solenoid operated: a high-speed electric motor driving through a series of reduction gears actuates the valves in either direction, in approximately ¼ second. There are no spring-returns, current-draining holding coils, or small pilot valves and orifices. Among features is a manual override which provides easy emergency operation by merely rotating cover of unit. "Motordyne" valves are not affected by variation



nd can be mounted in any position. Hydraulic system pressure is not required to hold valve open, which means that emergency or hand pump operation is not handicapped. Complete unit weighs 2.86 lbs. for he $\frac{3}{8}$" tube size valve. New units are said o offer maximum standardization and interchangeability because electrical unit fits on standard Pacific Division selector valves.—*Pacific Division, Bendix Aviation Corp., North Hollywood, 10, Calif.*

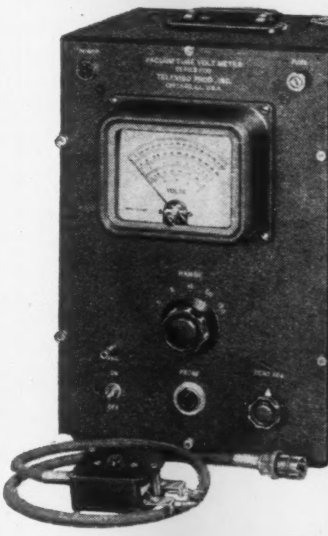
Broad-band Filter for Shielded Test Rooms

New power-line filter for use with screen-rooms prevents entrance of objectionable line noise at all frequencies from 150 kc. to 00 Mc. Originally designed to meet the severe performance requirements of undersigned Division for a line filter adequate to keep factory noise out of their own production and laboratory test rooms, new unit provides attenuation better than 60 db. over entire band. Designed for continuous operation at 500 volts d-c. or a-c. at a full load current of 100 amps., new broad-band screen-room line filter is available for installation n two-wire and three-wire circuits; is contained in a welded housing of 16-gage steel with knock-outs at each end to accommodate " conduit: a removable cover is attached y four screws. Ample space is provided in each end of housing for slack in connecting leads. Three-wire filter is 23" long × 12" wide × $4\frac{1}{8}$" deep; two-wire filter is 20" × " × $4\frac{1}{8}$". Electrical connection is made to " threaded studs at opposite ends of internal assembly. Frequency range and voltage and current capacity of these line filters are said to be ample for all present-day requirements in laboratory and production screen-rooms used in the testing and development of radio and other electronic products.—*Filterette Div., Tobe Deutschmann Corp., Canton, Mass.*

Gear Tooth Spacing Checker

New "Model No. 1130" precision gear checker, specifically designed for rapid checking of tooth spacing on gears, checks base pitch and tooth spacing along line of action on spur or helical gears. Spacing can also be checked on worm gears. Gears up to 2" O.D., and having a maximum shaft length of 18", may be checked. Operating principle is based on fact that distance between the two corresponding sides of adjacent teeth along line of action is equal to distance between corresponding sides of adjacent teeth measured on gear's base pitch circle. New "No. 1130" measures along line of action, thus indicating whether spacing is correct both along line of action and along base pitch circle. When setting up, fixed contact point and indicator contact point are set tangent to base circle on same sides of adjacent teeth. When so set, they will measure along line of action. A spring-actuated finger maintains a constant pressure to insure consistent accuracy. Gear is mounted between centers; headstock and tailstock are movable so that gear may be lined up readily with contact point fingers. Errors in spacing are shown directly on an indicator (see photograph) graduated in 0.0001". An indexing pawl operated through a single-

HIGHLY ACCURATE, STABLE VT VOLTMETER



features WAR RESTRICTED DEVELOPMENTS!

TELEVISO, pioneering in the production of measuring apparatus for the SONIC to UHF SPECTRUM, has specialized in building dependable Vacuum Tube Voltmeters.

A necessity wherever dependable voltage measurements within the range of 7 cps to 500 megacycles are required—the Televiso Series 200A VT Voltmeter is highly accurate and stable. IMPORTANT WAR TIME DEVELOPMENTS ARE AVAILABLE FOR THE FIRST TIME IN THE FOLLOWING FEATURES:

SUPERSENSITIVE RANGE—the lowest readable voltage is .05 volts on a maximum scale range of .5 volt.

FIVE VOLTAGE RANGES—.5, 2, 15, 50, 150—spread full scale on a $4\frac{1}{2}$" meter dial for easy reading. Accuracy of readings are 2% full scale; middle scale accuracy is 5% or better.

PROBE CONSTRUCTION—detachable probe to eliminate cable wear; easily dismantled for tube replacement or for soldering to tube terminals for measurements **in the 250-500 MC region; flat $\frac{1}{2}$" wide brass terminals connect to input to make easy soldering to test or work piece**; for low frequency work up to 100 MC, removable banana plugs are spaced $\frac{3}{4}$" center to center for use with standard jacks.

MECHANICAL CONSTRUCTION—of aluminum throughout; panel and cabinet are **$\frac{1}{4}$" thick (cabinet is dural.); sub-chassis is $\frac{1}{8}$" and spaced off the panel by studs to simplify servicing; all components are fastened to sub-chassis.**

ELECTRICAL CONSTRUCTION AND CIRCUIT—Series 200A utilizes the finest **components throughout and carries a two year guarantee. The circuit is a stable** plate circuit rectifier. No diode input tube is used. The plate circuit rectifier type makes available higher input impedance at all frequencies. No shorting of input probe is required for zero adjustments. All zero adjustments are made once and remain constant. A panel adjuster is available to make the unit usable without **heating up time. All filament and plate voltages are transformer and tube regulated.**

BUILT-IN CALIBRATION VOLTAGE—All units have a jack which produces a constant 6.3 volts for standardizing. This is the regulated filament voltage. The sensitivity can be adjusted without tools in the event tubes are replaced in the field. **The Series 200A will operate satisfactorily from any source of voltage from 95 to 130** volts a.c. Line voltage surges are not observable during use.

SIZE—14"H x $9\frac{1}{2}$"W x $7\frac{1}{2}$"D. Guaranteed 2 years. Price $170.00 F.O.B. Chicago

Televiso Products Inc.

7466 IRVING PARK ROAD • CHICAGO 34, ILLINOIS

Ingenious New Technical Methods

Available Now to Industry in General

Now! Projection Welding of Two Studs to Housing in One Operation!

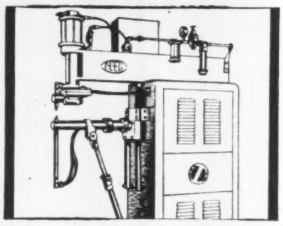
The series of P-20 Peer Welders were developed to provide manufacturers of sheet metal and wire products with automatically air operated machines capable of high speed precision projection and general spot welding. They are sturdily constructed, low priced, direct air operated, press type machines.

Shown above, is a Peer P-20 set up with safety guard which is so adjusted that, when lowered, it trips the switch and causes the welder to pass through a complete welding cycle before the machine automatically lifts the guard and stops, ready for the next operation. Other means such as a foot-switch control, can also be used to actuate the welding cycle.

The standard cylinders furnished with these welders provide nominal electrode force up to a maximum of 1000 lbs. Pressures are easily adjusted by the air pressure regulating valve. The welders may be operated with strokes suitable for work at hand within the range of from 0″ to 3″.

Shown at right, is the wrapper from a package of Wrigley's Spearmint Gum. This famous wrapper will remain empty until conditions permit Wrigley's Spearmint manufacture in quality and quantity for everyone. Wrigley's Spearmint Gum, will, one day, be back as "a help on the job" to workers in industry. Until then, we ask you to remember this wrapper as a guarantee of finest quality and flavor in chewing gum!

You can get complete information from Pier Equipment Mfg. Co., 8 Milton St., Benton Harbor, Mich.



Air Operated Press Type Spot Welder

WRIGLEY'S
SPEARMINT
CHEWING GUM

Remember this wrapper

Z-82

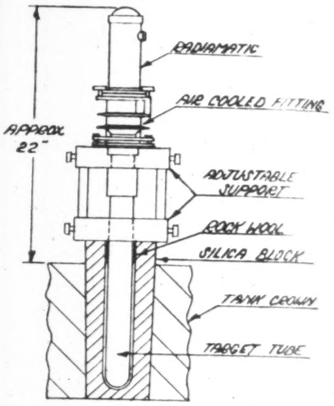
action lever (at left of machine) quickly and automatically indexes the gear from tooth to tooth. Gears having the same pitch and base pitch may be checked without changing set-up. Helical gears are checked in the transverse plane; normal plane may be checked by swiveling the indicator barrel to correct helix angle. "Model No. 1130" is designed so that the "Michigan AY-1 Recorder" can be used with it when user desires a chart record of the spacing of each tooth and also of the total variations in tooth spacing. A handwheel-operated rack and pinion permits indicator table to be quickly adjusted to line up contact points tangent to base circle. Gage blocks enable accurate adjustment of contact points. Adjustments are also provided to limit retraction of table when indexing from tooth to tooth. Overall height 50¼″; height to centers 42½″; floor space required 24″ × 33¼″. —*Michigan Tool Co., 7171 E. McNichols Road, Detroit 12, Mich.*

Non-linear Variable Resistors and Attenuators

New "Unit 736" is a non-linear wire-wound voltage-dividing variable resistor or "potentiometer" which, maker declares, has the highest degree of operating accuracy of any element of its kind. Accuracy of new element depends, of course, on shape of desired curve of resistance versus rotation, but maximum actual error in reproducing desired curve is said to be far less on each particular job than ever before attained. Tolerances of 0.5% or better have been consistently reached for certain curves. Higher accuracies are accomplished through new principles in design and precision manufacture. Other features of new variable resistor include great flexibility for reproducing any desired curve within certain limits; small size; long life with sustained accuracy; ability to replace more costly alternative circuits and components; definite contrib tion to simplification of existing equipmen Many firms now using so-called linear p tentiometers can replace them to advanta with new non-linear units, cutting expens by eliminating complicated eccentric gear This replacement would permit use of un form scales and give greater accuracy b cause back-lash would be done away wit New resistor was developed by Fairchi engineers for use in bridge T attenuato in company's air-borne electronic compu ing gunsight when it was found there we available no non-linear instruments of d sired accuracy. At present, Fairchild is pr ducing in quantities one standard size "Unit 736" with 1⅞″ O.D. This unit can used singly or stacked; it has been bank to 18 on one shaft. Linear units are al available. — *Fairchild Camera and Instr ment Corp., 88-06 Van Wyck Blvd., Jamai 1, N. Y.*

Silica Block for Radiation Pyrometer Installations

New single-hole silica block for measur ment of crown temperatures in glass tan has been developed for use with make "Radiamatic" radiation pyrometers, is sa



to have three additional advantages: (More constant calibration than is usual experienced with thermocouples; (2) Mo open scale divisions throughout operatin range; (3) Lower net cost: increased ser ice life of "Radiamatic" and its new a cessories will more than offset addition initial costs. New silica block is installe flush with inside roof surfaces, or with bo tom of block extending into furnace f several inches. "Radiamatic" receiver sighted into an 18″ Sillimanite target tu which is installed in the block to withi ¼″ of the bottom. An air-cooled fittin only is necessary to prevent overheating "Radiamatic" radiation receiver under no mal operating conditions. Target tube maintained under a slight positive pressu by connecting to a low-pressure air suppl Sillimanite target tube is accurately pos tioned by adjustment of the vertical su port. Annular opening between Sillimani tube and silica block is packed with ro wool or similar material to prevent acc mulation of batch dust.—*Brown Instrume Co., 4482 Wayne Avenue, Philadelph 44, Penna.*

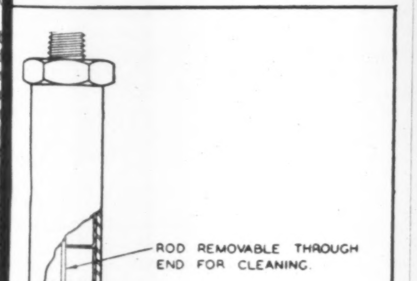
Photoelectric Smoke-detector fo Air-conditioning Systems

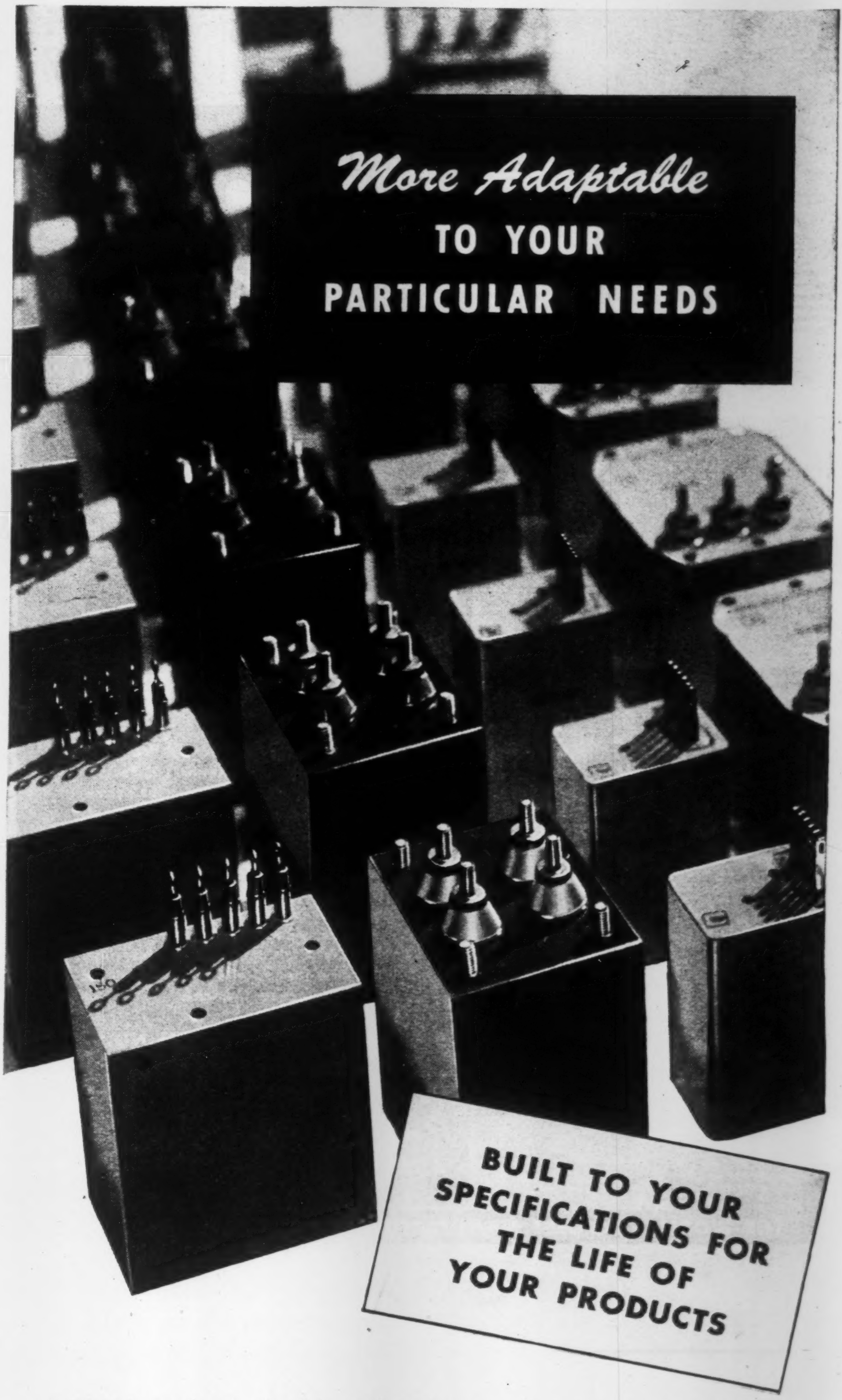
New photoelectric system detects pre ence of smoke in air-conditioning ducts an immediately sounds alarms, turns off blow ers, operates automatic dampers, or pro vides whatever other type of indication control is required. System consists of "Ph toelectric Control Type A26X" and "Lig Source Type L11RX." Latter may b mounted to project a beam of light over a distance from 10 to 25 feet to the "eye" the photoelectric unit. Sensitivity adjus ment on light source housing permits var tion in intensity of light beam, so that hotoelectric control will respond to smoke f a predetermined density. To provide complete protection, "Type A26X" is so designed that either current or tube failure ill cause it to operate as though light beam ere interrupted. Both units are available ither in Underwriter-approved explosion-roof housings for mounting in Class I. roup D hazardous areas, or in weather-roof pressed steel housings. "Type A26X"

perates from 115-volt 60-cycle a-c. and incorporates s-p.d-t. relay for normally-open normally-closed operation. Relay contacts are pure silver, designed to handle 10 amps. a.c. or 5 amps. d.c. at 5 volts. When using external power, maximum of 230 volts may be used the contacts if 1100 watts a.c. or 0 watts d.c. is not exceeded. Larger currents or higher voltages can be controlled rough use of an auxiliary power relay. ew system is designed to provide long rvice under severe operating conditions d should require no adjustments or maintenance other than normal vacuum-tube and ht-source lamp replacement on a six-onth schedule. — *Photoswitch, Inc., 77 roadway, Cambridge 42, Mass.*

Pulsation Damping Unit

New Pulsation Damping Unit is universal application, non-adjustable and delivers output pressure which is essentially ual to average flow of pulsating input essure. It is of a new type, different from y other. It has no moving parts, nor is ere need for any external adjustment to


ROD REMOVABLE THROUGH END FOR CLEANING.
ORIFICE
SCREEN FILTER AT BOTH ENDS.



THE know-how gained in engineering transformers to war's exacting specifications is now available to solve your peacetime transformer needs. Stancor engineers are ready to study and master the toughest problems you can set them. Production men trained to exacting standards, with modern equipment and precision winding machinery, assure that highest specifications will be met in the finished product.

When you have a transformer problem, think first of Stancor. Competent sales engineers are ready to satisfy your most exacting transformer requirements.

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1500 NORTH HALSTED STREET CHICAGO 22, ILLINOIS

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Sensory
TORQUE WRENCH
-HEAR-FEEL-SEE-

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THEY GAVE "OSCARS"

STURTEVANT Torque Wrenches would win highest honors . . . for outstanding performance . . . for permanent accuracy . . . for dependability and long tool life . . . *and for the development of the Sensory Wrench with "Reflex Torque Control"*—a truly great contribution to modern manufacturing.

Industry's recognition of P. A. STURTEVANT CO's achievements has made this firm the world's largest manufacturer of Torque Wrenches.

WRITE FOR BULLETIN NO. SW13

P. A. STURTEVANT CO.
ADDISON QUALITY ILLINOIS

THE WORLD'S LARGEST MANUFACTURERS OF TORQUE WRENCHES

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Instrument Engineer,

experienced in electrical recording instruments and movements, for permanent position in Development and Design Department of leading manufacturer, located in New England. State age, education, experience, salary expected. Box 98, Instruments Publishing Company, 1117 Wolfendale Street, Pittsburgh 12, Pa.

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We are not interested in the complex or devious solutions, but would prefer designs that are simple and obvious. Any individual or company that feels they have a device or gadget which has a reasonably large sales possibility should communicate with us. All correspondence will be held in the strictest confidence.

Box 99

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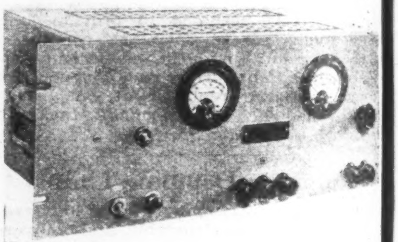
be made. It consists of a series of alternat small capacitances or volumes and orifices. As pressure wave enters device, a differential occurs across first orifice which cause a flow through it, thus raising pressure i adjacent chamber. This in turn causes flow through next orifice, producing simila effects except with decreased intensity While this "above-average" value of th pressure wave is making its way throug the series of chambers, the pressure drop below average value (since it is a pulsatin one) causing a reversal of the flow proces Thus it can be said that the various capac tances "breathe" with decreasing intensit as the waves pass through the damping uni until finally a point is reached where pres sure level lies just about at its averag value. It is important therefore that eac individual orifice provide the same drop fo the same flow, regardless of direction. T overcome difficulty of plugging, fine-mes screens are provided at both entrance an exit of damping unit. In addition, a ro which passes axially through series of ori fices can be readily removed, thus exposin a large orifice area for simple and effectiv cleaning. Device is completely free o gaskets and the caps are welded to th tubes to provide leak-proof constructio Unit is subjected to a static pressure te of 3,000 lbs./in.^{2} and bears a working pre sure rating of 100 lbs./in.^{2}. It is adapted t liquid or gas service by using one of tw rods supplied, selection of which is made a time of installation.—*Dep't B, Taylor In strument Companies, Rochester, New Yor*

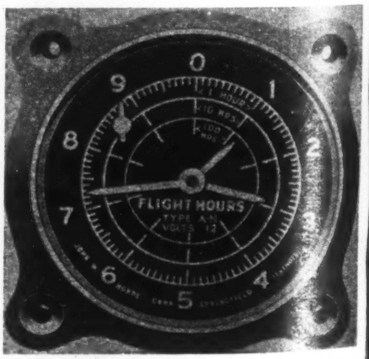
Power Supply

New "Model 200-B" Power Supply pro vides continuously-variable voltage plu regulation. Owing to its flexibility an ease of operation, it has a wide variety o applications in the laboratory and on th production line. *Voltages:* from 0-325 volt d.c. at 125 ma. continuously variable. 6. volts a.c. at 6 amps. center tapped. *Regula tion:* within 1% for voltages between 20-32 volts from no load to full load. Within 2 at 10 volts from no-load to full-load. *Hu Voltage:* less than 10 millivolts includin noise. *Indicated Output:* voltmeter and mil liammeter included to read output voltag and current.—*Electronic Measurements Co 10 West Front St., Red Bank, N. J.*



Flight Hour Meter

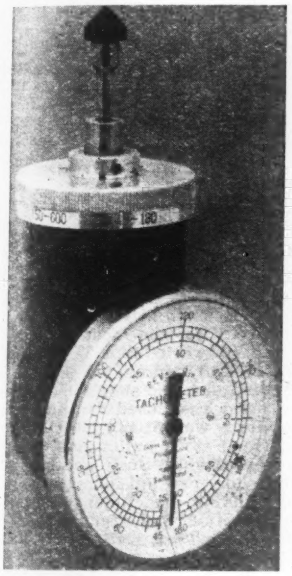
New Flight Hour Meter and Air Switc automatically logs actual flying time of an aircraft. Flight Hour Meter is quite simila to same manufacturer's Engine Hour Mete



(*Instruments*, April 1945, page 277) which is used to indicate hours of engine operation. It has three hands, one making a complete revolution in 10 hours, the second in 100 hours and the third in 1,000 hours. It can be mounted on the instrument panel, or placed out of sight of the operator, if desirable. Its operation is automatically controlled by the Hobbs Air Switch which is mounted on the inspection plate on the wing and is actuated by the air pressure developed when the plane, at take off, reaches a speed of approximately 40 m.p.h. Contact is maintained while in flight. When landing, and speed reduced to less than 40 m.p.h., switch automatically goes to "off" position. Flight Hour Meter is made for 6, 12 or 24 volts, direct current. It measures approximately 2[illegible]″ × 2½″ and weighs eight ounces. —*John W. Hobbs Corp., 2040 Yale Boulevard, Springfield, Illinois.*

Five-range Tachometer

New precision direct-indicating hand tachometer (of type and quality similar to model supplied by makers before the War) has two scales and five different r.p.m. ranges:

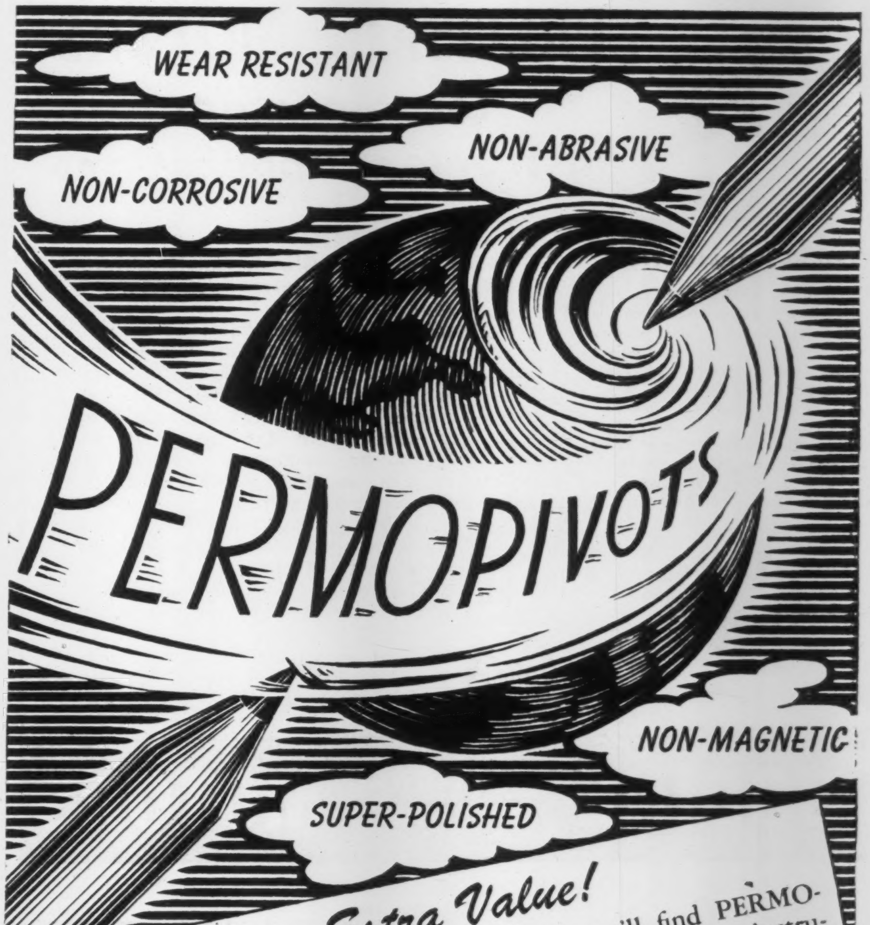


5 to 180; 150 to 600; 450 to 1800; 1500 to 6000 and 4500 to 18000. Change of range is by rotation of knurled barrel head. Instrument is supplied complete with carrying case and accessories, including a 6″ circumference wheel for measuring surface speeds.—*James G. Biddle Co., 1211 Arch St., Philadelphia 7, Pa.*

Self-regulating Power Pack

New "Model 1220 EB Pack" is designed for convenience in laboratory and experimental service, provides two 1% voltage-regulated d-c. outputs covering ranges com-

monly used for anode and bias voltages. High-voltage output is continuously adjustable from zero to 400 volts with voltage automatically held at its initial setting under load variation from zero to full current. Maximum current output on anode supply



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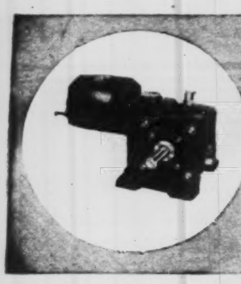
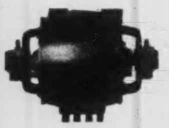


PRECISION MOTORS
for important instrument applications

TYPICAL APPLICATION

The motor shown here is an early Bodine Dynamotor which is still in use today after more than 20 years of continuous duty at the control center of the Chicago Fire Department. There are 125 of these Dynamotors which operate continuously to furnish 100 v direct current for the signal lines. This is convincing evidence of the dependability of Bodine motors.



Are you utilizing small motors to the fullest extent in developing your instruments? For example, accurate speed reductions in the instrument mechanism can be obtained with Bodine speed reducer motors. Over 2,000 standard frames and windings are available in sizes from 1/6 hp down to 1/2000 hp with speed reductions as great as 2880 to 1. The built-in motor speed reducer does away with instrument gear trains and provides space economies without sacrifice to efficiency.

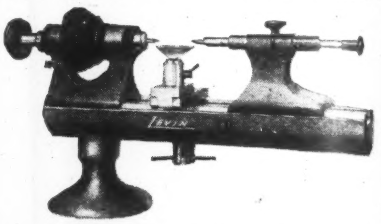
Bodine has helped instrument makers select and apply motors for over 40 years. Your inquiries will be given careful consideraion. Bodine Electric Company, 2244 W. Ohio St., Chicago 12, Ill.

BODINE FRACTIONAL HORSEPOWER MOTORS

is 250 ma.; maximum power output is 40 watts. Regulated bias voltage is continuously adjustable from minus [illegible] volts to zero at maximum current of [illegible] ma. Anode voltage and current are shown by 3″ indicating instruments on control panel; bias voltage is indicated by the setting of calibrated control. Anode and bias voltage outputs, as well as unregulated a-c output of 6.3 volts and 5 amperes, are delivered at safety jacks on the front of the control panel. Instrument and line fuses are replaceable from front of panel. Instrument is contained in a steel housing 13″ × 11″ × 9″ with ventilating louvres and a convenient carrying handle. All controls and ratings are clearly indicated on the reverse photo-etched front panel. Designed for trouble-free performance, the instrument is assembled with oil-impregnated oil-filled capacitors and is antifungus treated.—*Technical Apparatus Co., 1171 Tremont St., Boston 20, Mass.*

Precision Bench Lathe

New precision bench lathe is designed for use by instrument makers, model makers, tool makers or production departments where small or delicate work is handled. It has a hard steel spindle and bearings of double cone type. Swing is 3.94″ and length of bed is 12″. It is a rugged tool intended for continuous use and yet it has the necessary sensitivity for the most delicate watch or instrument work. Bed is ground to a master gage and is provided with a binding bolt which requires no shoe for attachments. Tip-over hand rest, used for hand turning, is made with a well-fitting joint to eliminate all play. Head stock pulley has 60 holes for indexing operations. Such accessories as a compound slide rest, milling attachment and traverse grinding attachment are available. —*Louis Levin & Son, Inc., 2206 Beverly Blvd., Los Angeles 4, Calif.*



Metal Sorter

New "Type AX Metalsorter" quickly identifies and sorts pure metals, steels and nonferrous alloys. It is portable, simple to operate, of rugged construction, requires no special electrical power supply and makes non-destructive tests on finished products. "Metalsorter" employs the tribo-electric effect: a metallic specimen of standard, known or acceptable character is rubbed against the surface of an unknown or doubtful piece. If a chemical or metallurgical dissimilarity of the two pieces exists, a minute electric

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current is generated and is registered by an indicator on a calibrated scale. When there is no dissimilarity, no electric current is indicated. Control unit of "Metalsorter" contains a thyratron-operated timing circuit, an electronic bias supply and a measuring circuit. A reciprocating tool is connected to the control unit by means of a multiple-conductor cable and plug. This tool is provided with a specimen-holding chuck and a flexible lead for connection to the metal to be tested. Various fixtures, tools and connector leads are standard accessory equipment to enable the "Metalsorter" to use almost any shape of metallic part for a reference standard. When "Metalsorter" is carried from one place to another, tools and accessories are housed in the control unit cabinet. Entire instrument is enclosed in a canvas felt-lined cover. Weight complete is about 40 lbs. Device may be used on all shapes and sizes in the mill, warehouses, receiving and shipping platforms, laboratory, or production and assembly lines. Since "Metalsorter" test is absolutely non-destructive, it may be applied to the identification of built-up machinery and aircraft assemblies and structures. The fact that the pieces being tested are in metallic and electrical contact with adjoining members does not affect the accuracy of the test.—*Farmers Engineering & Mfg. Co., 549 Brushton Avenue, Pittsburgh 21, Penna.*

Propeller-type Meter for Hot Water

New "Propeloflo Meter" is available for metering hot water up to 250°F. It is similar to cold-water model described and illustrated in *Instruments*, July 1944, page 444. A special high-temperature grease is employed for efficient lubrication. Venturi design and all other special features of this streamline propeller-type meter are retained. The "Propeloflo" is said to be extremely useful where a simple totalizing meter is desired.—*Builders-Providence, Inc., (Division of Builders Iron Foundry) Providence 1, R. I.*

High-vacuum Gage with Built-in Condensable Vapor Trap

Completely redesigned McLeod type portable high-vacuum gage is announced. It is stated that accurate readings, within the micron range, are obtainable with this instrument even when condensable vapors, such as water, oils and alcohol are present in the vacuum systems. This is accomplished by means of a built-in renewable chemical cartridge, which protects the gage by absorbing all such vapors. A change of color in the chemicals indicates when they are saturated and cartridge renewal is necessary. (In most applications this would be after several months of service.) Other features: a simple device for fine adjustment of automatic zero point; a shut-off valve to permit the gage to be kept under vacuum, without danger of contamination, when not in use for actual measurement; an improved slotted bracket to enable the gage to be readily removed from one permanent mounting to another and for use as a portable instrument; also new type fittings to minimize amount of rubber tubing or other connections which could give rise to "outgassing" or leaks; and plastic case of mod-

STOKES
STOKES

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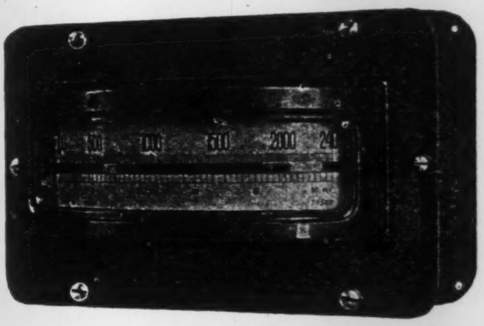

WALL TYPE W-1

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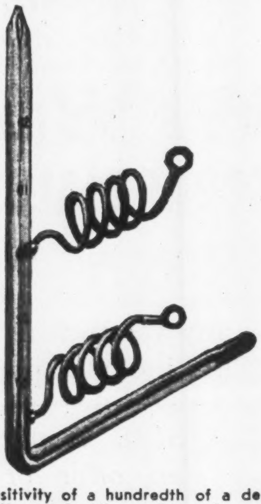

- Sensitivity of a hundredth of a degree is easily attainable. ● Top of mercury column visible at control point (where most important) because electrodes terminate at back of tube. No encircling metal bands! ● Available in angle form (illustrated) or conventional straight form. ● Send for brief, attractive bulletin.

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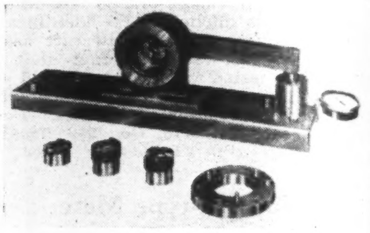
ern design. Manufacturer states that reading the gage is as simple as reading a thermometer and that even inexperienced help can read the instrument rapidly and accurately. Available in two rugged, safely portable models: 0 to 5000 microns (5mm.) and 0 to 500 microns. Applications:—in plant or laboratory, wherever means for accurately measuring vacuum within the micron range is necessary; to check quality of products being processed, to know whether or not a vacuum system is tight and functioning properly; to determine efficiencies of vacuum pumps and other equipment, etc.—*F. J. Stokes Machine Co., Philadelphia 20, Pa.*

Aircraft Engine Starter Tester

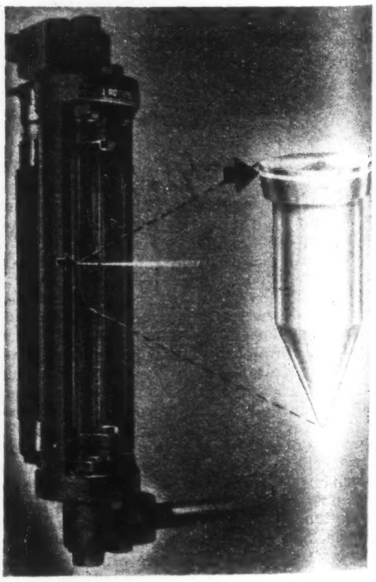
New "Model A-760" aircraft engine starter tester is a compact portable test unit that can be easily bolted to work bench for testing clutch settings on starters used with



engines up to 1000 in.^{3} displacement. Unit consists of a one-piece casting, mounted on a 7″ steel channel. To hold starter to be tested, a 5″ diam. mounting plate and one 3-tooth starter jaw with torque arm and piston and gage assembly are furnished as standard equipment. Foot pounds of torque are registered on torque gage which is connected to piston assembly. Accessories which can be supplied as needed are: right or left hand 3-tooth starter jaws for 5″ diam. mounting plate, right or left hand 3-tooth starter jaws for use with 4″ diam. mounting plate, 4″ diam. mounting plate, retracting motor jaw, low torque cylinder and gage for use with retracting motor units. Complete unit is 7″ wide, 11″ high and 28″ long, weighs approx. 85 lbs.—*Airplane Manufacturing & Supply Div. of Pacific Airmotive Corp., 6853 Lankershim Blvd., North Hollywood, Calif.*

Illuminated Rotor for Rotameters

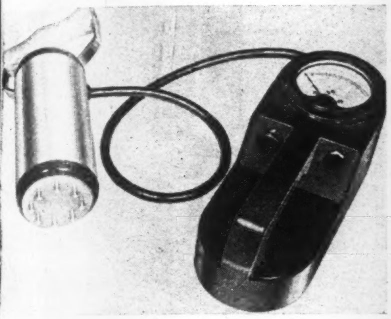
New "Line-o-Light" rotor is especially well suited for sharp, clear Rotameter readings of opaque liquids. Of the same basic design as a standard SK rotor, it has a disk of light-transmitting material sandwiched in the rotor head which substantially re-



duces the distance that the light must travel through the opaque liquid from its source behind the tube. Rate-of-flow is thus delineated sharply in the resultant band of light on the tube reference scale and operators can make easy, accurate readings. "Line-o-Light" rotor can be used for practically any application and in any type tapered glass tube rotameter. Two types of disks can be furnished: Lucite for general applications and Pyrex glass for extremely hot or highly corrosive fluids.—*Schutte & Koerting Co., 12th & Thompson Sts., Philadelphia, Pa.*

Moisture Tester for Curved Surfaces

New "Model K-2" Moisture Register, for testing a wide variety of materials having curved, rough or flat surfaces, incorporates a new type electrode equipped with buttons individually spring-cushioned to allow every button to maintain contact regardless of the contour of the material tested. It is in addition to the model long established for testing lumber and other flat surfaces. "Model K-2" is especially adapted for testing the following materials: paper in stacks or rolls of varying diameters; bolts; rolls or stacks of cloth; rough lumber; plaster and other materials having curved or irregular surfaces. "Model K-2," like all other Moisture Registers, operates on the principle of power absorption from a high-frequency oscillator circuit. A characteristic of the instrument is its ability to determine low moisture percentages, actually providing readings down to zero percent. Accurate moisture checks with "Model K-2" can be made by anyone in three seconds or less. Instrument is portable, weighs 5 lbs and is supplied with a convenient carrying case.—*Moisture Register Co., 133 North Garfield Ave., Alhambra, Calif.*



Bench Hydraulic Press with Automatic Cycling

New "Multipress" empodies what is reported to be a new and revolutionary principle of vibratory hydraulic pressure, whereby rapidly- or slowly-repeated application of regulatively uniform hydraulic pressure upon a moving element is produced. New principle makes it possible to regulate ram's movements so that it will automatically make any number of repeated pressure strokes upon the work. By depressing control lever, the ram is caused to descend upon the work from its full upstroke limit and, without further movement of the controls, automatically make short, repeated, uniform-pressure strokes until control lever is released, whereupon ram rises to its full upstroke position and stops. Pressures to be exerted by ram in repeat strokes can be regulated and preset for any value between 1600 and 8,000 lbs. (latter figure being maximum capacity of 4-ton "Multipress" which is used here for descriptive purpose). Number of those strokes can be from one to infinity. Frequency of repetitive stroRes is influenced by ram speeds; also by stroke length or distance of ram travel, which is closely regulative from a few thousandths to ½". For example, "Multipress" will deliver 500 four-ton repeat

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250-450 VOLTS

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Other G-E regulated power-supplies are available in the following ranges: **180-300 volts 160-1500 volts Dual Regulated**

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Teleoptic Directional Signals for the highway are made to the same standards of accuracy and dependability.

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TIMING MIN. 5 SEC.
COIL MOM-24 V. DC CY.
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COMPACT:
4 IN HIGH
2½ IN DEEP
2½ IN WIDE

WEIGHT:
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Unique construction enables operator to rapidly determine temperature even on minute spots, fast moving objects, or smallest stream; no correction charts, no accessories, no maintenance expense. Special "FOUNDRY TYPE" and "Universal TRIPLE RANGE" have, in addition to standard calibrated range, a red correction scale determining TRUE SPOUT and POURING TEMPERATURES of molten iron and steel when measured in the open.

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All three types can be furnished with capacities ranging from 20 TO 200 AMPERES PER POLE.

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INTERVAL TIMERS, or PROCESS TIMERS, are furnished in two types. One is reset by hand (manual); other resets itself, automatically. Both types can be provided for practically any cycle of time, fully adjustable from zero to maximum period. SYNCHRONOUS, SELF-STARTING MOTORS.

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SIGNAL TIMERS

Used extensively for starting and stopping industrial work; school class periods; for municipal time signals, etc. Fully adjustable over 24-hour period in steps of five minutes. Sunday and Holiday Cutout and Manual Control.

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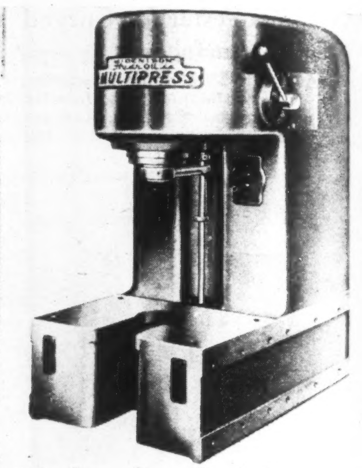
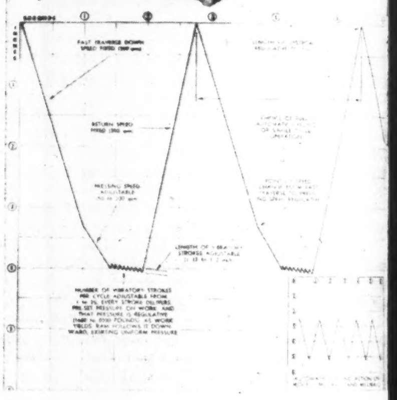
strokes per minute at its ⅛″ stroke settin Any shorter setting of length of repea strokes, increases their frequency until, at 0.004″ setting, ram movement becomes virtually high-frequency vibration and near imperceptible to the eye. Furthermore, regardless of how much the work may b compressed, or compacted, during this repeated and rapid application of short pressure strokes, the ram will follow it downward, exerting the same uniform pressu constantly. *Automatic Cycling*, an accessor control feature, when used in conjunctio with vibratory pressure principle, afford




MULTIPRESS
FAST TRAVERSE DOWN
RETURN SPEED
PRESSING SPEED ADJUSTABLE
LENGTH OF VIBRATORY STROKES ADJUSTABLE
NUMBER OF VIBRATORY STROKES PER CYCLE ADJUSTABLE FROM 1 to 25. EVERY STROKE DELIVERS PRE-SET PRESSURE ON WORK AND THAT PRESSURE IS REGULATIVE. AS WORK YIELDS RAM FOLLOWS IT DOWNWARD, EXERTING UNIFORM PRESSURE

even more unusual ram actions. For example, by means of a single control lever th hydraulically-powered ram will descen contact the work, make any pre-set numbe of uniform-pressure repeat strokes betwee 1 and 25, rise to the pre-set upstroke limi and immediately descend again to repea that operation continuously until contr lever is moved back to idling position. single-cycle position of the lever is availabl for use during set-up work. *Dimensions* New "Multipress" is a streamlined, completely self-contained, bench-size oil hydraulic machine which has a daylight opening of 12″; a work table of 16″ × 10½″; throat opening of 6″; overall dimensions o 16″ × 26″ × 34″; and weighs 745 lbs. Ra speed can be regulated from 20 to 200 inche per minute. Stroke length and ram pressu are accurately controllable. Free of an projecting parts, unit is especially suited t gang-type arrangement in minimum spac Power is furnished by a 3-hp. electric motor. A 6-ton unit of the same size and general specifications is also announced.—*Dennison Engineering Co., Columbus, Ohio.*

Chart Drive Cut-out

New chart drive control embodies mean for automatically starting and stopping electronic recorder chart motion by pen position. This chart drive cut-out will be available for undersigned company's circula chart "Electronik" Recorder. Control con

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220
160
240
140
120
250
100
EASY TO READ
DIAL THERMOMETER
INDICATES
TEMPERATURE
POWERS
SELF-OPERATING TYPE
1½
HIS VALVE CONTROLS HEATING OR COOLING MEDIUMS
Fuel-Saving Starts With CONTROL

Use a Powers No. 11 Temperature Indicating Regulator when you want the advantages of an easy-to-read dial thermometer combined with a dependable self-operating regulator. The dial thermometer gives a visual check on the performance of the regulator and makes it easy to adjust for the required operating temperature. Various dials and ranges are available.

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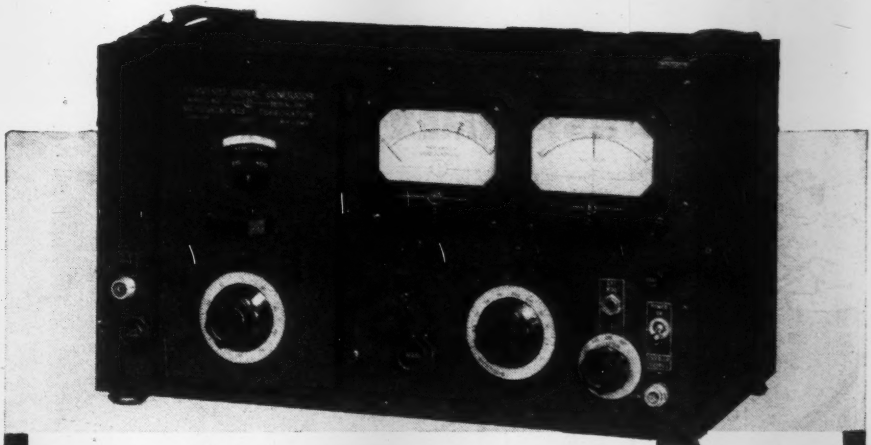
OF AUTOMATIC TEMPERATURE AND HUMIDITY CONTROL



STANDARD SIGNAL GENERATOR Model 80

SPECIFICATIONS:

CARRIER FREQUENCY RANGE: 2 to 400 megacycles.
OUTPUT: 0.1 to 100,000 microvolts. 50 ohms output impedance.
MODULATION: A M 0 to 30% at 400 or 1000 cycles internal.
Jack for external audio modulation.
Video modulation jack for connection of external pulse generator.
POWER SUPPLY: 117 volts, 50-60 cycles.
DIMENSIONS: Width 19", Height 10¾", Depth 9½".
WEIGHT: Approximately 35 lbs. **PRICE**—$465.00 f.o.b. Boonton.
Suitable connection cables and matching pads can be supplied on order.

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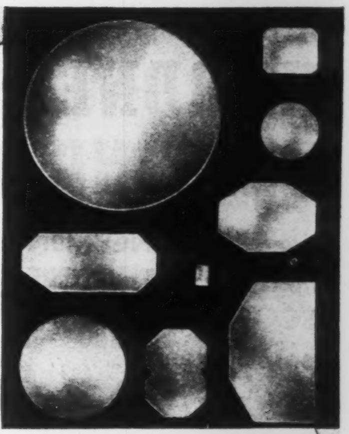

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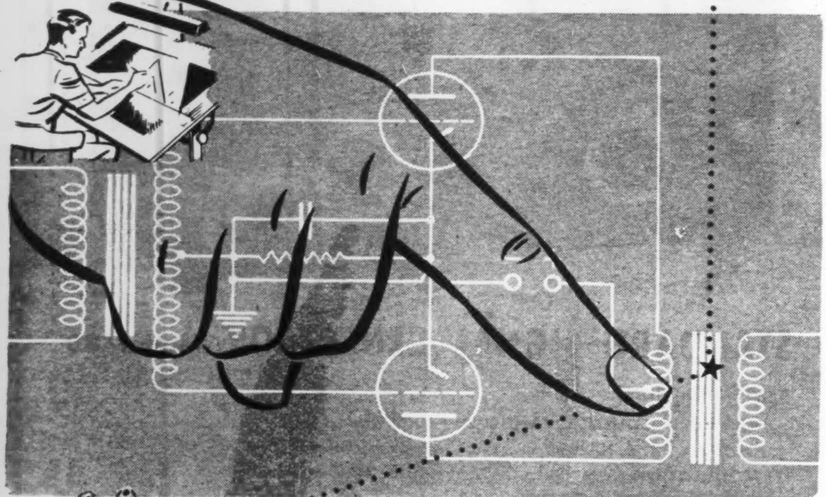

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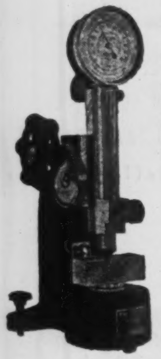

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setting control point, chart can be stoppe
and started as desired, corresponding to an
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couple and radiation pyrometer applications
—*Brown Instrument Co., 4482 Wayne Ave*
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in the mechanisms of bomb releases, is ap
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automotive, railway, marine, communica
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is available. These rotary solenoids are use
in the bomb shackles of all Mustang fighte
planes built during the last year and a hal

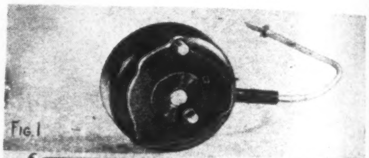

FIG. 1

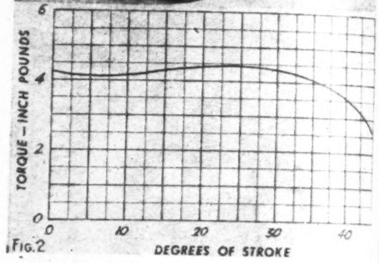

FIG. 2

Fig. 1. "Ledex" Solenoid as installed in bomb release. Diameter is 1⅞"; height, ¾".
Fig. 2. Test curve of solenoid used in illustrated bomb release.

Hundreds of thousands have been installe
in other planes and various military instal
lations. Bomb release solenoid (see Fig. 1
is smaller in diameter than a man's pocke
watch and about twice as thick. For a give
amount of material and current, it deliver
many times the power of conventional solen
oids. When magnet is energized, rotary mo
tion is imparted to upper member of solen

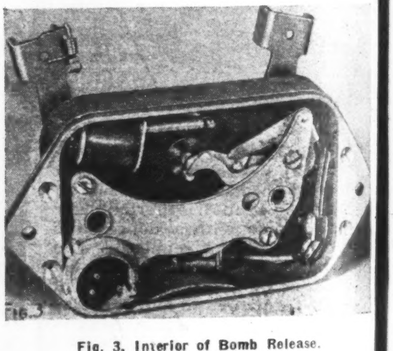

FIG. 3

Fig. 3. Interior of Bomb Release.

oid. The torsional power of rotating mem
ber is in excess of four inch-pounds (se
Fig. 2). In the bomb release application
(see Fig. 3) a lever rests upon a pin ¼
from axis of solenoid, where force is mo
than 16 lbs. The instant an electrical conta
is made, pin is turned through a 45° a
allowing lever to drop and thereby actuati
mechanism of bomb release. Beside savi
space and weight, new solenoid meets gov
ernment requirements of immunity to acc
dental operation through shock. This ja
proof feature is one of the advantages whi
especially commended the solenoid to ai
craft engineers. "Ledex" rotary solenoi
can be manufactured in a wide range
capacities. The size of the device in ea
instance will be small in relation to i
power.—*George H. Leland, 113 Webster S*
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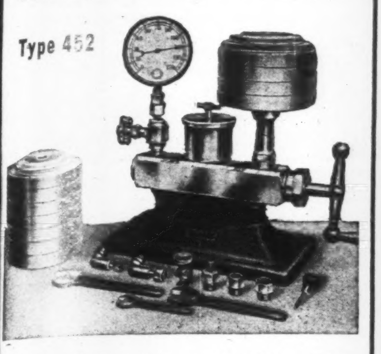
Type 452



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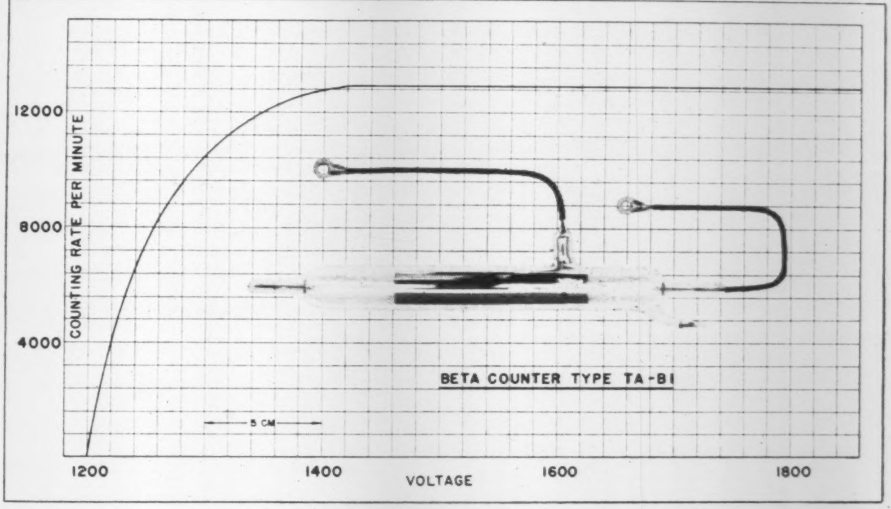

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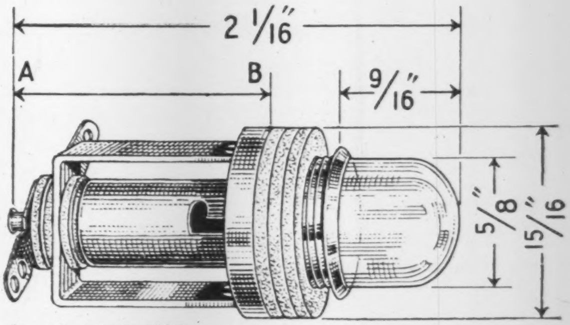

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INSTRUMENT SOCIETIES CALENDAR

City, Society and Secretary			Date	Place	Subject	Speaker
Atlanta, Georgia	Georgia Society for Measurement & Control	Robert E. Geminert, P.O. Box 1714, Atlanta		Blue Flame Room, Atlanta Gas Light Co.		
Baltimore Maryland	Baltimore Industrial Instrumentation Society	F. Ragan, Fuel Div., Beth Steel, Sparrows Pt., Md.	Sept. 27(D)	Engineers Club, 6 W. Fayette St., Balto.	(Business and social meeting)	
Charleston, W. Va.	Charleston Instrument Society	M. B. Lorig, 1506 Virginia St., Charleston 1	Sept. 10 Oct. 1	Daniel Boone Hotel (To be announced)	(To be announced) Flowmeters and Kindred Subjects	E. S. Lee A. F. Benson
Chicago, Illinois	Chicago Section, I. S. A.	A. J. Butler, c/o IHC, 2626 W. 31st Blvd., Chicago	Sept. 10	M&M Club, 237 Merchandise Mart	Vibration, its measurement and control	Dr. R. O. F
Cleveland, Ohio	Cleveland Instrumentation Society	A. J. McCullough, Minneapolis-Honeywell, 5005 Euclid Ave., Cleveland 3	Sept. 19(B)	Cleveland Engineering Society	(To be announced)	Speaker from Bailey Meter Co
Detroit, Mich.	Instrument Society of Detroit	Cliff Sackett, Chrysler Eng'g 12800 Oakland Ave. Det't				
Florence, Alabama	Muscle Shoals Instrument Society	J. W. Moffett, 323 E. Mobile St., Florence				
Fort Worth, Texas	Fort Worth Electronics Club	Ralph Ely, 1116 E. Arlington, Fort Worth		Texas Hotel, Fort Worth		
Gulf Coast (Texas)	Gulf Coast Section, I. S. A.	C. D. Holt, 2509 Lake Shore Dr., Port Arthur, Texas				
Hartford, Conn.	Hartford Society for Measurement & Control	Gustave L. Manke, c/o Veeder-Root, Sargent & Garden Sts.	Oct. 16(B)	Bond Hotel	(To be announced)	
Kansas City, Missouri	KC Industrial Instrumentation Society	Gordon H. Burke, 1527 Broadway, Kansas City, Mo.	Sept. 25 Oct. 30	Bluebird Cafeteria Bluebird Cafeteria	Control Valves Flow Measurement Eng'g	G. Thomason Mason-Neilan Reg. Co. L. K. Spink, Foxboro
Los Angeles, Calif.	California Instrument Society	M. D. Pugh, 541 South Spring St., Los Angeles, Calif.	Sept. 9(C)	Melody Lane, Los Angeles	X-ray Inspection Equipment	Dr. L. W. Ball
Newark, N. J.	Society for Measurement & Control (New Jersey)	H. L. Close, 831 Dixie Lane, Plainfield, N. J.	Oct. 2	Essex House	Air-operated control and applications	E. R. Huckman
New York, N. Y.	New York Society for Measurement & Control	H. L. Hildenbrand, 206-07 33d Ave., Bayside, L.I., N.Y.	Sept. 24	Columbia U. Men's Faculty Club, 400 W. 117th St.	Electrical Instruments	L. F. Parachini, Weston Elec. Instrument Co.
N. Indiana	Northern Indiana Section, I. S. A.	Chas. P. Haynes Red River Oil Refinery 935 — 177th Place Hammond, Indiana	Sept. 17(C) Oct. 19(C)	Ultramodern Dining Rm. 4607 Indplis Bld., E. Chi. Lake Hotel, 740 Washington St., Gary	Basic Principles of Indust'l Electronics Pneumatic Null Balance Applied to Ind'l Instr's	A. G. Mohaupt, DeForest's Training, Inc C. B. Moore, Pres., Moore Products
Philadelphia, Pa.	Philadelphia Society for Instrumentation	G. E. Gress, c/o ATC, 34 E. Logan St., Philadelphia	Sept. 19(B)	Broadwood Hotel, Broad & Wood Sts.	(To be announced)	T. F. Robertson, Corning Glass Works
Pittsburgh, Pa.	Pittsburgh Section, I.S.A.	L. M. Susany, c/o Carnegie Institute, 4400 Forbes St.	Sept. 24(B) Oct. 22(B)	Roosevelt Hotel Roosevelt Hotel	Electronic instruments for process control Instrumentation in Plant Design and Constr'n	D. M. Nielson, The Foxboro Co. F. H. Trapnell, Du Pont
St. Louis, Mo.	St. Louis Society for Instrumentation	Gus Holubeck, Union Electric Co., Venice, Ill.	Sept. 25(C)	DeSoto Hotel, 11th & Locust Sts.	Discussion on Automatic Control	Four experts
Kingsport, Tenn.	Tennessee Section, I. S. A.	C. F. Palmer, 2924 J. C. Hwy., Kingsport				
Toronto, Ontario	Canadian Society for Measurement & Control	T. C. Agnew, Minneapolis-Honeywell Reg. Co.		Diana Sweets, 188 Bloor St. W., Toronto		
Washington, D. C.	Instrument Society of Washington	W. A. Wildhack, National Bureau of Standards, Wash'n	Sept. 25(D)	Interior Dep't Auditorium	Synthetic Training Devices	Comdr. D. L. Hibbard U.S.N.R.
Whiting, Indiana	Whiting Instrument Men's Guild	Lloyd Clouse, 7344 Dante Ave., Chicago 19, Illinois				
Wyandotte, Mich.	Instrument Society of Wayne County	Wilson Fox, 33 Chestnut St., Wyandotte, Mich.	Oct. 22(B)	West Mound Methodist Church	Telemetering	Perry Borden, Bristol Co.

(A) Meeting at 7:30, no dinner (B) Dinner at 6:30, meeting at 8 (C) Dinner at 7, meeting at 8 (D) Meeting at 8, no dinner

ST. LOUIS

The following officers were elected by the Executive Committee of the St. Louis Society for Instrumentation, at a meeting held on June 15, 1945, to serve for 1945-1946:

Chairman: Wm. E. Boyle, Shell Petroleum Corp., Wood River, Ill.

Vice Chairman: E. W. Markwardt, Western Cartridge Co., East Alton, Ill.

Secretary: H. E. Zeffren, Union Electric Co., St. Louis, Mo.

Treasurer: R. W. Dodson, Geo. S. Mepham Corp., East St. Louis, Ill.

The following committee chairmen were also elected at this meeting:

Program: Hans Freeman, Economy Equipment Co., St. Louis, Mo.

Membership: M. B. Roberts, The Brown Instrument Co., St. Louis, Mo.

Hospitality: R. H. Munch, Monsanto Chemical Co., St. Louis, Mo.

The first meeting of the year will be held the latter part of this month. We will advise you of the subject and date as soon as determined.—H. E. ZEFFREN, *Secretary.*

WYANDOTTE

The August meeting of the Instrument Society of Wayne County was a joint picnic with the Detroit Chapter. We met at Rouge Park and spent an hour or so in getting acquainted and visiting. The Detroit folks brought a P.A. System which was very useful in keeping things going. We set out the picnic lunch and the refreshments and took good care of that part of the program. A number of prizes were contributed by the societies and by some companies. There was an interesting schedule of contests, enlivened by the P.A. System. About fifty people were present and everyone had a fine time. —JOHN MACPHERSON, *Vice President.*

INSTRUMENT SOCIETY of AMERICA

President *pro tem:* Albert F. Sperry, 225 N. Michigan Ave., Chicago, Ill.

Vice President *pro tem:* Professor Carl Kayan, Columbia University, New York City.

Treasurer *pro tem:* Clarke E. Fry, 2331 Meadow Drive, Pittsburgh 21, Penna.

Secretary *pro tem:* Richard Rimbach, 1117 Wolfendale St., Pittsburgh 12, Penna.

For Committees see May issue of *Instruments,* pages 296-297.

I.S.A. ANNOUNCEMENTS

By RICHARD RIMBACH, *Sec'y pro tem*

EMPLOYMENT CLEARING HOUSE

The Employment Service offered by the Instruments Publishing Company has been taken over by Employment Clearing House of The Instrument Society of America.

Local Employment Committees, consisting of a chairman and two members, have been appointed by each local section. These committees will make every effort to contact the companies in their localities who are employing instrument men.

The Employment Clearing House will be glad to hear from employers who need instrument engineers or men. A letter specifying the requirements will receive immediate attention.

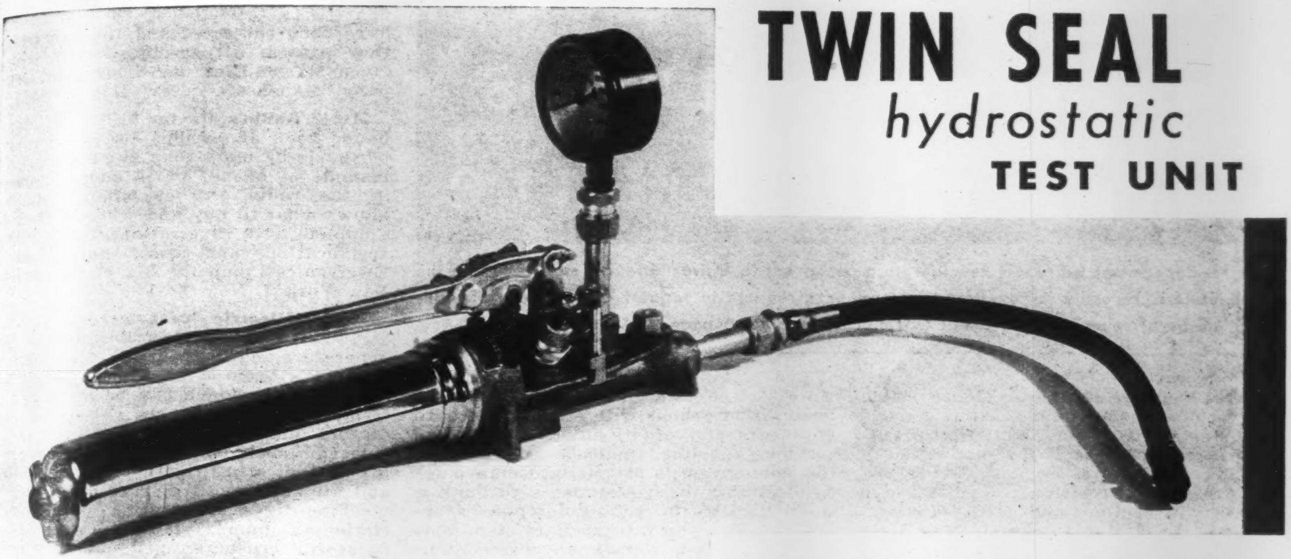
Instrument men who have been released by war plants can obtain a registration form by applying to the National Office of the Instrument Society of America, 1117 Wolfendale St., Pittsburgh 12, Pa.

I.S.A. FALL MEETING

The Fall Meeting of the I.S.A. is now scheduled to take place on October 19, 20, and 21, in Pittsburgh, Pa., instead of in Detroit, as originally planned. The plans have been changed owing to the fact that this gives the members attending this meeting an opportunity to attend the Educational Instrumentation Conference, sponsored jointly by the Carnegie Institute of Technology and the I.S.A., which will be held October 16, 17, and 18 (the three days preceding the planned I.S.A. Conference).

All members of I.S.A. are invited to attend the Instrumentation Conference, but it is suggested that those who decide to attend write to Dr. Teare, the head of the Conference, and an invitation will be extended to them.

A notice describing the Conference is at-



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tached, and the program for the week will be as follows:

October 16, 17, 18—Educational Instrumentation Conference.

October 19—Meetings of all standing Committees of I.S.A.

October 20—Business meeting of I.S.A. Delegates.

October 21—Officers and Committee meetings, to discuss future plans.

CONFERENCE ON INSTRUMENTATION IN THE UNIVERSITIES

An educational conference on instrumentation sponsored by the Carnegie Institute of Technology and The I.S.A. has been arranged for October 16, 17, and 18.

The program will be divided into two parts. The first part covers the requirements expected by industries and the second part will be devoted to present training in instrumentation.

The Chairman of the Committee is Dr. B. R. Teare, Jr., Head of the Department of Electrical Engineering of the Carnegie Institute of Technology, Pittsburgh 13, Pa.

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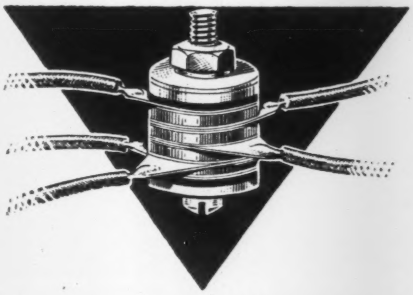
for one experienced in design and production of optical instruments. Write in confidence, giving full particulars, qualifications, etc., to Box 95, Instruments Publishing Co., 1117 Wolfendale St., Pittsburgh 12, Pa.



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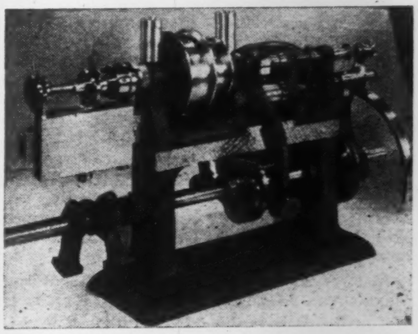

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Manufacturers' New Literature

In this department we report new literature pertaining to Instrumentation, received from the manufacturers. To assist in the War Effort we urge readers to request ONLY those bulletins which will be of value to them. Use the coupon on the facing page.

M-231 **"Science of Measurement."** Home study course consisting of eight lessons for industrial and vocational gage training programs. These 6″ × 9″ booklets are entitled as follows. Book 1 (24 pages) "Progress in Precision"; Book 2 (20 pages) "Inspection and Care of Gage Blocks"; Book 3 (24 pages) "The Uses of Gage Blocks"; Book 4 (20 pages) "Accessories of Precision"; Book 5 (28 pages) "The Sine Bar and Its Uses"; Book 6 (28 pages) "Measuring to a Millionth with Optical Flats"; Book 7 (48 pages) "The Do All Comparator and Threads and Gears"; Book 8 (28 pages) "The Mobile Inspection Unit and How to Set-Up a System." Hundreds of photographs show inspection and engineering methods utilizing height gages, locating gages, go-no-go gages, inside and outside micrometers, lead screw measuring gages, scribers, dividers and the new mobile inspection unit. Tables and formulas make simple such problems as measuring pitch diameter of screw, splines, and helical gears by the three wire method, and measuring of angles, bevels and tapers by use of the sine bar. The eight lessons are spaced to cover a two-month period. Mailings are made direct to the homes of inspection personnel on the basis of one lesson each week. Continental Machines, Inc., 1301 Washington Avenue S., Minneapolis 4, Minnesota.

M-232 **"Apparatus for D-c. Resistance Measurements."** 36-page 8½″ × 11″ Catalog E-53 covers an expanded discussion of equipment and listing of specifications. Presents d-c. resistance bridges and the standards, galvanometers, accessories, etc., usually chosen for use with them. Instruments for a wide variety of applications will be found, including models for the most precise measurement, as well as those designed especially for routine testing, student instruction and many others. Each instrument is listed and completely described so that prospective purchasers can easily choose the items best suited for their specific use. Leeds & Northrup Co., 4934 Stenton Avenue, Philadelphia 44, Pennsylvania.

M-233 **Radio and Electronic Products.** 8-page 8½″ × 11″ Catalog No. 968 lists many items of variable capacitors, plugs, jacks, inductors, chokes, terminals, tube sockets, couplings, antenna equipment, and RF insulators. E. F. Johnson Company, Waseca, Minnesota.

M-234 **Accurate Fixed Wire-Wound Resistors.** 28-page 8½″ × 11″ Engineering Bulletin R is a complete guide to accurate fixed wire-wound resistor selection and use in all types of modern equipment. Also included are data on resistance alloys, maximum resistance and temperature coefficient charts, dimensional specifications, mountings and terminal designs, power dissipation, moisture- and fungus-proofing data, hermetic sealing information and full data on Shallcross "Akro-ohm" resistor types. Shallcross Mfg. Co., Collingdale, Penn.

M-235 **Pulse Service Capacitor Nomograph.** 4-page 8½″ × 11″ Technical Bulletin No. 11 offers a pulse service capacitor nomograph which will prove helpful to engineers and others involved in pulse service capacitor applications. Although the nomograph is primarily designed for determining the voltamperes through a capacitor used in rectangular pulse service, it first, as an intermediate step, finds the d-c. (unit pulse) energy content which, in some cases, may be sufficient. Sprague Electric Company, North Adams, Massachusetts.

M-236 **Battery Products.** 80-page 8½″ × 11″ Engineering Manual lists and describes the complete line of batteries manufactured by the Burgess Industries. The principal headings are Batteries for Flashlights, Ignition, Telephone, Radio (farm and portable) Blasting, and Earphones. Also covered are exhaust and intake snubbers, spark arrester-snubbers, intake silencers, air cleaners, cleaner-silencers, accousti-booths, flashlights, lanterns, stereotype mats and illium. Burgess Battery Company, Freeport, Illinois.

M-237 **"Three American Microscope Builders."** 78-page 6″ × 9″ book published to memorialize three early microscope builders—to point with pride to their achievements, with the hope that men and women who are using or building such instruments today will fully appreciate the dominant position of, and the splendid opportunities before, the American optical industry. American Optical Company, Scientific Instrument Division, Buffalo, New York.

M-238 **Precision Hydraulic Equipment.** 4-page 8½″ × 11″ folder describes and illustrates hydraulic aircraft 4-way selector valve, "Isodraulic" remote control, solenoid 4-way pneumatic valve, solenoid shut-off valve, fluid metering pump, hydraulic hand pump and relief valve. Adel Precision Products Corp., Burbank, California and Hunting, West Virginia.

M239 **"The CD Capacitor."** 16-page 5″ × 8″ May issue Vol. 10, No. 5, of this house organ features (1) Magic-eye V-T voltmeter, (2) "Modernize your Oscilloscope" and (3) five pages of Radio Trading Post wherein articles connected with radio are listed for sale, trade, swap, and wanted. Cornell-Dubilier Electric Corp., Hamilton Boulevard, South Plainfield, New Jersey.

M-240 **Pyrometer Controllers.** 16-page 8½″ × 11″ Bulletin PB1226 describes the new "Microact" and other electric-type "Pyromaster" controllers. The several different types of controllers are illustrated, contact and load circuit wiring diagrams are given and typical applications are indicated. The Bristol Company, Waterbury 91, Connecticut.

M-241 **Glass-to-metal Hermetically-sealed Electrical Indicating Instruments.** 12-page 5″ × 8″ illustrated brochure explaining the history, uses and advantages of glass-to-metal truly hermetically-sealed electrical indicating instruments. The book further describes the heating process used to seal glass to metal, and illustrates the various stringent tests to which these instruments have been subjected and through which they passed. All specifications are also given. Marion Electrical Instrument Company, Manchester, New Hampshire.

M-242 **Radio's Master** 8½″ × 11″ cloth-bound book of perhaps 800 pages (numbering is by more than 20 sections) is a manual of official parts and equipment of the radio and electronic industry. Shows what to buy and where to buy it. Complete with illustrations, descriptions, specifications and prices. Sun Radio & Electronics Company, 212 Fulton Street, New York 7, New York.

M-243 **Electric Tachometers.** 12-page 8½″ × 11″ booklet describes tachometer generators and instruments, for rotational speeds from 1 to 60,000 r.p.m. and linear speeds which can be measured in terms of r.p.m. From the variety of generators and instruments available, suitable equipment can be selected for recording or indicating the speed of steel-mill and aluminum-mill drivers, all types of machine tools, automotive and aircraft engineers, pumps, fans, blowers, compressors, crushers, grinders, turbines, paper machines, and many types of pulverizing, separating, hoisting and conveying machinery. — General Electric Company, Schenectady, N. Y.

M-244 **Radio and Electronic Equipment.** 36-page 8½″ × 11″ catalog contains pertinent information and data on the most advanced types of electronic instruments, devices and tools. Descriptions are given of products such as industrial x-ray machines, an electronic comparator, signal generators, tube testers, multitesters, photoelectric devices, dieless duplicating tools, lastic sectional wiring systems and many others that have been cataloged before. Walker-Jimieson, Inc., 311 South Western Ave., Chicago 12, Ill.

M-245 **Determination of Liquid Level by Volume or Weight.** 8-page 8½″ × 11″ bulletin EX-101 describes construction, operation and application of a new series of instruments of laboratory standards designed for commercial use for hydrostatic measurement of liquids in storage, blending and mixing tanks containing oils, chemicals, paints, food products, etc. Capacities of the nine basic models range from 38″ of water for model "TR-12" up to 41″ for model "TM-35." Scales graduated in gallons, pounds, inches of depth, barrels or other units are offered as standard. King Engineering Company, Ann Arbor, Michigan.

M-246 **Electrically-operated Switches.** 116-page 8½″ × 11″ Circular No. 600 outlines the major features of the "Asco" line of electrically-operated switches and emphasizes the importance of their basic designs, especially the mechanically-locked mechanism and the inherent electrical and mechanical interlocking. Automatic transfer switches, remote control switches, panel and switchboard mountings. Contactors and relays are illustrated and described. Automatic Switch Co., 41 East 11th St., New York 3, New York.

M-247 **Precision Level Control of Boiler Feed-water.** 32-page 8½″ × 11″ booklet presents a complete line of automatic feed-water level controllers, high- and low-water alarm signals, and low-water cut-offs. Diagrams show the operations of all parts of the controls described. Featured is "Micro-Bean," a dampener universal in application for all purposes up to 3000 pounds, which will not pinch off and will give any degree of stabilization desired by turning the micro-valve. J. A. Campbell Co., 645 E. Wardlow Rd., Long Beach 7, Calif.

M-248 **Electric Furnaces for Laboratory and Industrial Use.** 4-page 8½″ × 11″ folder covers the design, construction and specifications of a muffle furnace for heat-treating small parts — for those shops that depend on commercial heat treaters or having only large furnaces. It is claimed that unusual uniformity of chamber temperatures is secured by rapid heat diffusion and power concentration at heat loss points. Cooley Electric Mfg. Corp., Indianapolis 4, Indiana.

M-249 **Surface Wear Due to Rubbing Abrasion.** 16-page 8½″ ×11″ booklet gives information on the abraser tester, its action and the results obtained. It is claimed that this instrument gives, in a matter of minutes, data which closely parallels what would be found by actual and time-consuming service tests and provides a standard value for the wearability of materials and surfaces. A few typical examples of materials whose wear factors can be readily determined are paints, lacquers, rubber and synthetic materials, electroplate, leather, linoleum and textiles. Taber Instrument Corp. North Tonawanda, New York.

M-250 **"Seeing It Through."** 56-page 7″ ×10″ booklet dedicated to the thousands of Bausch and Lomb employees in armed forces and war workers in the factory who through their patriotism and loyalty, competence and coöperation have established a record of which they may be justly proud. Bausch & Lomb Optical Co., Rochester, N. Y.

M-251 **"The Experimenter."** 8 - page issue of this house organ (designated as Vol. 19, No. 11) contains the following articles: (1) Microflash shows flight defects in projectiles. (2) Measuring 0.003 horsepower with the Strobotac, and (3) Phototube capacitance measurement with the type 650-A impedance bridge. General Radio Company, 275 Massachusetts Ave., Cambridge 39, Mass.

M-252 **Petroleum Gas Testing Apparatus.** 12-page 8½″ × 11″ booklet describes in detail the following instruments: Recording gravitometer, gas gravity balance, dew point tester, vapor pressure bomb, specific-gravity bomb, torsion balance, corrosion test bomb, total sulphur method, portable dead weight gauge tester, pulsameter and specific gravity hydrometers. The Refinery Supply Co., 621 E. 4th St., Tulsa 3, Oklahoma.

M-253 **Temperature Control Cabinets.** 48-page 8½″ × 11″ Catalog 325 describes with numerous illustrations a complete line of constant temperature equipment. The standard cabinets include electrically-heated ovens for laboratory drying, plastics, preheating, conditioning, and rubber aging. Included are also sterilizers, incubators, paraffin embedding ovens, low temperature cabinets, humidity control and steam heated explosion proof cabinets, vacuum ovens, and combustion-tube furnaces for laboratory use. General information is given on mechanical and gravity convection heat transfer. Precision Scientific Company, 1750 N. Springfield Ave., Chicago 47, Ill.

M-254 **Phase Sequence Indicator and Voltage Testers.** Bulletins 401 and 402, 8½″ × 11″, 2 pages each, for catalog D, enumerate the salient features of these instruments and discusses in detail the applications. The primary function of the phase sequence indicator is to indicate the order of succession in time of the different voltage peaks of a multiphase supply and in addition enables one to make continuity tests. The voltage testers are handy instruments for measuring circuit voltages and for determining whether circuits carry a.c., pure d.c. or rectifier d.c. Electrical Facilities Inc., 4224 Holden St., Oakland 8, Calif.

M-255 **Hydrostatic Gage Test Unit.** 6-page 8½″ × 11″ folder describes and illustrates the design and action of the twin seal hydrostatic test unit equipped with twin seal check valves. The twin seal principle means a metal-to-metal seat, the same seal as in conventional cone poppet types, plus a resilient ring seal on the poppet. When the valve is

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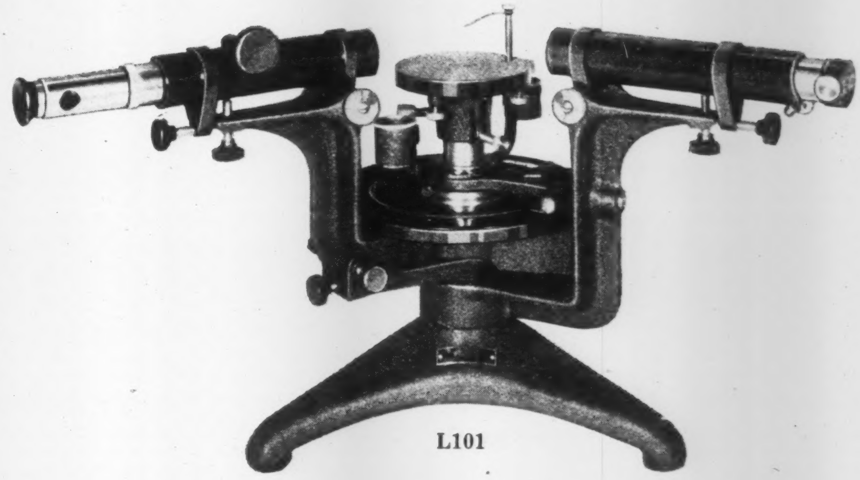

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